United States Department of Agriculture

Animal and Plant Health Inspection Service

FY 2006

Wildlife Services Ongoing Research & Development

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New Technologies to Deter Wildlife from Airports and Aircraft

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National Wildlife Research Center Scientists Modify Airport Habitats and Study Adjacent Land Uses

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research facility devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and acceptable methods, tools, and techniques. NWRC's field station in Sandusky, OH, is dedicated to providing a scientific foundation for WS programs that reduce wildlife hazards at airports throughout the United States.

In order to be certified for commercial passenger traffic by the Federal Aviation Administration (FAA), many U.S. airports are required to develop and implement a wildlife hazard management plan. The FAA strongly discourages any management practice that might increase wildlife in the vicinity of an airport. NWRC's research is focused on understanding the nature of wildlife hazards at airports, developing management tools to reduce those hazards, and providing WS and airport personnel with information on the latest strategies for controlling wildlife hazards.

Major Research Accomplishments:

- WS partnered with private industry to develop and patent devices to alert birds to the presence of aircraft.
- WS partnered with private industry to test the effectiveness of electric mats as a wildlife deterrent.
- WS established the efficacy of an endophyte-infected tall fescue variety and Zoysiagrass (warm season grasses native to China, Japan and other parts of Southeast Asia) in reducing foraging by Canada geese.

Applying Science and Expertise to Wildlife Challenges

Wildlife Habitat Management and Other Land-Use Studies at Airports—Habitat management is fundamental to reducing wildlife use of airfields. NWRC scientists have been studying vegetation types and vegetation management practices for airports to determine if there are management schemes and vegetation varieties that are undesirable for food and loafing by birds and other wildlife. Canada geese foraged less on endophyte-infected tall fescue and Zoysiagrass than alternative types of grass that were offered. Fescue cannot be grown everywhere; therefore, further research has been initiated to determine which varieties grow best in specific geographic and climatic conditions. Water detention/retention and waste management facilities near airports are being investigated to determine which features of those facilities make them attractive to wildlife. Proper design and management of water and waste management facilities can reduce their attractiveness to wildlife that are potential hazards to aviation.

Wildlife Deterrents— NWRC scientists investigated a prototype electric mat designed to keep deer from entering fence openings where gates are left open or cannot be used. The electric mats reduced white-tailed deer intrusions by 95% during a 6-week test in winter, indicating that they might provide a suitable alternative for locations on airfields where gates or traditional cattle guards cannot be used or are undesirable. The mats are about half the cost of traditional cattle guards.

In addition, NWRC scientist investigated a vehicle-based lighting system that produces an emission spectra covering peak visual capabilities of white-tailed deer, and qualified real-time avoidance behavior of free-ranging deer exposed to a combination of the lighting treatments and vehicle approach. The scientist are considering both the physical properties of the lighting treatments and looming effect on deer response. The findings from this research have implications for both ground-based vehicles and aircraft during landing and takeoff phases.

NWRC scientists are also investigating the efficacy of gull effigies for dispersing gulls from landfills and other locations near airfields. Because landfills are very attractive to gulls, a combination of control measures is often required to minimize the risk posed to aviation. Effigies can serve as an additional non-lethal tool.

Avian Visual Deterrents—Lasers, pulsed landing lights, and warning patterns have been tested for their effectiveness at deterring birds. NWRC and private industry jointly hold one U.S. patent and have another patent pending on devices to visually deter birds from aircraft. This ongoing research is aimed at determining the capabilities of avian visual perception. The ultimate goal is to develop visual deterrents that make aircraft more noticeable to birds. These visual deterrents are also applicable to reducing avian mortality at wind turbines, communication towers, and other structures.

Radar Monitoring of Avian Hazards—WS scientists are evaluating the use of marine radars, typically used on ships, in conjunction with visual observations to assess and monitor avian hazards to aviation. These radars and tracking software allow biologists to monitor hazardous bird movements at night and over larger areas than traditional visual observations. Because the data are archived by the software, they can be reviewed for patterns of movement over days, weeks, and seasons. Such information can aid biologists in identifying and locating previously unknown wildlife attractants.

Groups Affected by This Problem:

- Airline passengers
- Airline pilots
- Airline administrators
- Airport operators
- Aircraft and engine manufacturers
- Insurance underwriters
- Residents near airports

Major Cooperators:

- Airline Pilots Association
- Port Authority of New York and New Jersey
- Federal Aviation Administration
- Western Washington Airports
- U.S. Air Force Bird Air Strike Hazard (BASH) Team at Kirtland Air Force Base
- U.S. Air Force
- U.S. Marine Corp
- U.S. Dept. of Navy
- National Association of State Aviation Officials
- Electric Power Research Institute
- Precise Flight

Selected Publications:

Seamans, T.W., S.C. Barras, G.E. Bernhardt, B.F. Blackwell and J.D. Cepek. 2007. Comparison of 2 vegatation-height management practices for wildlife control at airports. Human-Wildlife Conflicts 1:97-105.

Blackwell, B. F., and S. E. Wright. 2006. Collisions of red-tailed hawks (Buteo jamaicensis), turkey (Cathartes aura), and black vultures (Coragyps atratus) with aircraft: implications for bird strike reduction. Journal of Raptor Research 40:76-80.

Seamans, T. W. and K. C. VerCauteren. 2006. Evaluation of ElectroBraid fencing as a white-tailed deer barrier. Wildlife Society Bulletin 34:8-15.

Seamans, T. W. 2005. Response of roosting turkey vultures to a vulture effigy. Ohio Journal of Science 105:136-138.

Beason, R. C. 2004. What can birds hear? Proceedings of Vertebrate Pest Conference 21:92-96.

Blackwell, B. F. and G. E. Bernhardt. 2004. Efficacy of aircraft landing lights in stimulating avoidance behavior in birds. Journal of Wildlife Management 68:725-732.

Blackwell, B. F., B. E. Washburn, and M. Begier. 2004. Evaluating population management scenarios: crunching the numbers before going to the field. Proceedings of Vertebrate Pest Conference 21:306-311.

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White, R. J. and B. F. Blackwell. 2004. Ineffectiveness of sulfur-based odors as nesting deterrents against European starlings. Ohio Journal of Science 104:126-128.

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Defining Economic Impacts and Developing Strategies for Reducing Avian Predation in Aquaculture Systems

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National Wildlife Research Center Scientists Address Aquaculture Losses

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research facility devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and acceptable methods, tools, and techniques. NWRC's field station in Starkville, MS, is located in the heart of the primary aquaculture producing area of the southeastern United States and was established to develop methods to reduce the impacts of fish-eating birds on aquaculture stocks.

In the past 30 years, populations of fish-eating birds have increased dramatically and caused substantial economic impacts to aquaculture production. Aquaculture industry costs associated with bird damage and damage prevention are estimated to exceed $25 million annually for double-crested cormorants alone. The goal of NWRC's research is to determine the impact of fish-eating birds on aquaculture production and natural resources, and to develop methods to reduce depredation of southeastern catfish, baitfish, and crawfish industries. Current research is aimed at gaining information about the abundance, distribution, and foraging behavior of fish-eating birds, the economic impacts associated with their foraging activities, and the diseases they transmit at aquaculture facilities. This information will help to develop new techniques for reducing damage.

Major Research Accomplishments:

- WS documented the impact of cormorants on the catfish industry. This research was used to develop a Standing Depredation Order for the control of cormorants on farms in 1998, an Environmental Impact Statement, and 2 depredation orders for control of cormorants in winter roosts and breeding areas to protect aquaculture and natural resources in 2003.
- WS and their cooperators demonstrated that American white pelicans are a host of the Bolbophorus trematode, which can be devastating to the catfish aquaculture industry.
- WS demonstrated that low-powered lasers can disperse double-crested cormorants from night roosts adjacent to catfish farms.

Applying Science and Expertise to Wildlife Challenges

Population Trends—NWRC scientists are studying population trends and movement patterns of double-crested cormorants and American white pelicans, by tracking large-scale movements through the use of telemetry and banding techniques. This research will provide a better understanding of population trends and bird movements and will be used to evaluate various alternatives for managing impacts of these birds on southeastern aquaculture and natural resources.

NWRC scientists recently evaluated the distribution and abundance of double-crested cormorants at catfish aquaculture ponds in the Delta region of Mississippi. Results demonstrated that cormorants used these ponds extensively during January through April, with the greatest economic damage occurring in February and March. During this study, cormorants consumed an estimated 1,775 and 1,347 metric tons of catfish in the Delta region of Mississippi in 2000-2001 and 2003-2004 respectively. These losses translated into a cost of up to $13.2 Million for 2001 alone. This study provides a biological basis for estimating economic losses caused by cormorants on a large scale.

Biology and Impact of Fish-Eating Birds on Aquaculture—An understanding of the biology of fish-eating birds and their economic impacts on aquaculture will enable the successful application of various management strategies. For example, given the feeding preferences of double-crested cormorants, American white pelicans, great blue herons, little blue herons, and great egrets, NWRC researchers are working to develop economic threshold predictions to determine their impacts on aquaculture production.

Changes in the catfish aquaculture industry have resulted in changes in production systems and dominance of multiple-batch farming. This type of aquaculture involves growth of multiple size classes of fish simultaneously in the same pond and periodic harvest of market-ready fish. NWRC scientists have initiated research to address these production changes and characterize the impacts of foraging by captive double-crested cormorants on channel catfish in multiple-batch cropping systems. NWRC scientists will integrate the results of studies of cormorant habitat-use patterns with detailed studies of foraging impacts to investigate the potential for economic impacts from cormorant depredations and suggest management strategies to alleviate the damage.

Developing Methods for Reducing Damage to Aquaculture and Natural Resources—As part of an integrated approach to reduce the impact of fish-eating birds on southeastern aquaculture, several tools have been developed. Field studies documented the effectiveness of low-powered lasers for dispersing double-crested cormorants from night roosts near aquaculture facilities while minimizing disturbances to waterfowl and other non-target species. NWRC research on the economic impacts of cormorant foraging led to the issuance of two migratory bird depredation orders. These orders enable aquaculture producers and wildlife managers to manage local cormorant populations that are causing damage to aquaculture and natural resources.

NWRC biologists are working with WS operations personnel to determine the behavioral responses of cormorants to different management activities. In collaboration with the Michigan Department of Natural Resources, WS initiated a study in the Les Cheneaux region of Michigan in 2004 in response to localized depeletions of harvest-sized yellow perch in the region. Information is being collected on perch populations, cormorant habitat use, and cormorant reproductive parameters in specific bodies of water where perch problems have persisted. It will be combined with investigations of cormorant diet patterns and cormorant behavioral response to specific management strategies including egg-oiling, nest destruction, and limited control of adult cormorants. Preliminary results show a near elimination of cormorant breeding success, a marked decline in cormorant numbers, and an increase in young age classes of yellow perch in the region. These studies will help determine the role of cormorants in perch depletion and whether cormorant management can effectively reverse these trends.

American White Pelican Disease Ecology NWRC researchers, in collaboration with parasitologists at two state universities, the Thad Cochran Warmwater Aquaculture Center, and the Southern Regional Aquaculture Center, completed studies to determine the species of trematode infecting catfish in the southeastern United States and to determine whether fish-eating birds serve as hosts for this parasite. Biologists at the NWRC Mississippi field station artificially infected captive American white pelicans with larvae of Bolbophorus spp. trematodes. Results showed that American white pelicans can potentially transmit this disease among catfish ponds. Double-crested cormorants, great blue herons, and great egrets did not appear to serve as hosts for these trematodes. Recent results indicate that a relatively low infection of trematodes in pelicans can result in large numbers of trematode eggs deposited into catfish ponds. This study underscores the importance of preventing pelican use of aquaculture facilities.

Groups Affected by These Problems:

- Aquaculture producers, distributors and retailers
- Sportfish guides and outfitters
- Wildlife managers

Major Cooperators:

- Catfish Farmers of America
- Cornell University
- Michigan Department of Natural Resources
- Mississippi State University, College of Veterinary Medicine
- Mississippi State University, Department of Wildlife and Fisheries
- Mississippi Agricultural and Forestry Experiment Station
- Delta Research and Extension Center, Thad Cochran National Warmwater Aquaculture Center
- New York Department of Environmental Conservation
- Southern Regional Aquaculture Center
- Vermont Fish and Game Department

Selected Publications:

Fallon, J. A., R. L. Cochran, B. Dorr, and H. Klandorf. 2006. Interspecies comparison of Pentosodine accumulation in birds. Auk 123: 870-876.

Werner, S. J., and B. S. Dorr. 2006. Influence of fish stocking density on the foraging behavior of double-crested cormorants Phalacrocorax auritus. Journal of the World Aquaculture Society 37: 121-125.

Anderson, D. W., D. T. King, and John Coulson (Eds.). 2005. The Biology and Conservation of the American White Pelican. Waterbirds 28 (Special Publication 1): 112 pages.

Barras, S. C., and K. C. Godwin. 2005. Control of bird predation at aquaculture facilities: frightening techniques. Southern Regional Aquaculture Center Publication. Number 401:4 pp.

Werner, S. J., J. B. Harrel, and D. E. Wooten. 2005. Foraging behavior and monetary impact of wading birds at Arkansas baitfish farms. Journal of the World Aquaculture Society 36:354-362.

Dorr, B. S.; King, D. T.; Tobin, M. E.; Harrel, J. B.; Smith, P. L. 2004. Double-crested cormorant movements in relation to aquaculture in eastern Mississippi and western Alabama. Waterbirds 27:147-154.

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Evaluation of Wildlife Conservation Plots, Repellents and DRC-1339 Take Models for Management of Blackbirds and Starlings in Sunflower Fields, Feed Lots and Dairies

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National Wildlife Research Center Scientists Address the Concerns of Sunflower Producers and Feedlot Managers

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research facility devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and acceptable methods, tools, and techniques. NWRC's field station in Bismarck, ND, is ideally located to study methods for managing regional blackbird damage to sunflower crops in the Great Plains. The field station also assists with national problems involving European starling damage and diseases in urban areas and at feedlots and dairies.

Blackbirds and starlings damage grain crops and eat livestock feed, causing significant economic losses to agricultural producers. NWRC scientists are studying ways to refine current damage abatement methods and develop new methods for reducing damage. Additionally, researchers are looking to expand capabilities to target specific problem-causing blackbird populations on both local and regional scales with predictable results.

Major Research Accomplishments:

- WS developed a strategy to plant Wildlife Conservation Sunflower Plots to reduce damage to commercial sunflower fields and provide habitat for other animals.
- WS developed a model to estimate the avicide DRC-1339's effectiveness and impact on starling populations.
- WS discovered two chemical compounds - one that is currently registered as an insecticide for sunflower and one in development - that might discourage blackbirds from feeding on sunflowers.

Applying Science and Expertise to Wildlife Challenges

Conservation Sunflower Plots—During the last decade new farm programs have placed more emphasis on wildlife conservation. From 2004 to 2006, WS and North Dakota State University scientists collaborated to evaluate decoy sunflower plots, called Wildlife Conservation Sunflower Plots (WCSP). The objective of WCSP is to reduce damage to commercial fields by providing blackbirds an attractive nearby alternative food source. A secondary benefit is provision of a safe-haven for other wildlife that use shelterbelts and wetlands along the edges of sunflower fields. The majority of birds recorded using WCSP during a recent study were blackbirds, but 43 non-blackbird species also were recorded. Use of WCSP resulted in significantly lower damage in nearby commercial sunflower fields. In 2004, 2005, and 2006, bird damage to sunflowers in the WCSP was 39%, 32%, and 60%, respectively, compared to 5%, 4%, and 18%, respectively, in nearby commercial fields. These results indicate that WCSP can reduce bird damage in nearby commercial fields.

Ongoing studies are evaluating the use of geographical information systems for improving placement of WCSP and maximizing the benefits of this environmentally-friendly wildlife damage management concept.

Starling Population Management Modeling—Urban areas, feedlots and dairies are major gathering sites of European starlings in the winter. Starlings eat valuable livestock feed; defecate on livestock, facility superstructures, feeder troughs and feed; and are a potential reservoir of diseases transmissible to livestock and humans. WS personnel manage starling numbers with an avicide, but lack a standardized methodology to estimate mortality at feedlots and dairies. NWRC scientists developed a bioenergetics model for estimating bird mortality during baiting operations. The information will be used to document the avicide's effectiveness and impact on target species.

Repellents—NWRC researchers are working to identify, develop, and improve the use of chemical repellents for reducing blackbird damage to ripening sunflower crops. From 2003 to 2006, NWRC scientists conducted feeding tests with captive black-

birds to evaluate 12 potential bird repellents. Two compounds - caffeine and garlic oil - showed sufficient repellency to warrant field testing. However, before any repellent can be used effectively in large-scale applications, a more effective method is needed to spray repellents onto sunflower heads, which hang perpendicular to the ground.

Groups Affected By These Problems:

- Sunflower producers
- South Dakota Oilseed Council
- North Dakota Department of Agriculture
- South Dakota Department of Agriculture
- Feedlot Owners Association
- Consumers of sunflowers, sunflower seeds, sunflower oil, and other products
- Processors, manufacturers, suppliers, and sellers of sunflower products

Major Cooperators:

- National Sunflower Association
- North Dakota State University
- North Dakota Department of Agriculture
- Kansas Feedlot Association
- Indiapolis Downtowners Association

Selected Publications:

Hagy, H. M., J. M. Raetzman, G. M. Linz, and W. J. Bleier. 2005. Decoy cropping methods for luring blackbirds away from commercial sunflower: USDA wildlife conservation sunflower plots. Wildlife Damage Management Conference, May 16-19, 2005, Traverse City, Michigan.

Homan, H. J., G. M. Linz, R. M. Engeman, and L. B. Penry. 2005. Spring dispersal patterns of red-winged blackbirds (Agelaius phoeniceus) staging in east-central South Dakota. Canadian Field-Nat. 118:201-209.

Linz, G. M., D. A. Schaaf, P. Mastrangelo, H. J. Homan, L. B. Penry, and W. J. Bleier. 2004. Wildlife conservation sunflower plots as a dual-purpose wildlife management strategy. 21st Vertebrate Pest Conference, March 1-4, 2004, Visalia, California. Pg. 291-294, Proceedings of the 21st Vertebrate Pest Conference.

Werner, S. J., H. J. Homan, M. L. Avery, G. M. Linz, E. A. Tillman, A. A. Slowik, R. W. Byrd, T. M. Primus, and M. J. Goodall. 2005. Evaluation of Bird Shield as a blackbird repellent in ripening rice and sunflower fields. Wildlife Soc. Bull. 33:251-257.

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Development of Repellents and Other Techniques for Managing Blackbird Depredations to Rice

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National Wildlife Research Center Scientists Address Blackbird Damage to Rice

Wildlife Services'(WS) National Wildlife Research Center (NWRC) is the only Federal research facility devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and acceptable methods, tools, and techniques.

Major Research Accomplishments:

- WS completed a rice producer survey of blackbird damage to rice in Louisiana, Arkansas, Missouri, California and Texas.
- WS evaluated the efficacy of Aza-Direct, GG-orange terpene, caffeine, GWN-4770, GWN 4140 and Tilt® EC as potential blackbird repellents for use on rice seed and ripening rice to reduce blackbird damage.
- WS evaluated alternative baiting strategies for the effective and safe delivery of DRC-1339, an avicide for the control of depredating blackbird populations.
- WS determined DRC-1339 dietary effects on several species of non-target birds.
- WS determined blackbird response to several concentrations of DRC-1339.
- WS determined residue levels of DRC-1339 in soil and plants.
- WS determined the potential hazards of DRC-1339 to non-target bird species.
- WS developed and validated an empirical model to estimate the take of target birds from WS' blackbird/DRC-1339 baiting program in Louisiana, Missouri, and Texas.
- WS determined the movements and distribution of blackbird populations causing damage to rice crops in Missouri, Arkansas and Louisiana.

Red-winged blackbirds, common grackles, and brown-headed cowbirds cause an estimated $13.4 million worth of damage to newly planted and ripening rice in Arkansas, California, Louisiana, Missouri, and Texas. Some individual growers report 100 percent losses due to bird depredation. NWRC scientists routinely work with rice producers, rice commodity groups, rice research boards, universities, and local, State and Federal agencies to develop safer and more effective methods to reduce bird depredation on seeded and ripening rice and improve profitability for growers. To develop new methods and tools, NWRC scientists conduct multifaceted research studies involving the use of both captive and free-ranging birds to determine the status of blackbird populations in the southern rice-growing states, estimate the economic impacts of birds on the rice crop, evaluate and develop nonlethal repellents for deterring birds, and improve the effectiveness and safety of avicides for reducing depredating populations.

Applying Science and Expertise to Wildlife Challenges

Chemical Repellents—NWRC scientists conducted a series of laboratory and field tests to identify, formulate, and evaluate potential nonlethal repellents for reducing bird damage to newly-planted and ripening rice. Of many chemicals tested, GWN–4770, GWN–4140, caffeine, and Tilt® EC have shown the most promising results. Development and registration of a chemical repellent for seeded or headed rice could have a major

impact on reducing damage losses and environmental hazards and increasing efficiency and profitability of production.

DRC-1339 Baiting—DRC-1339 is an avicide used in the management of blackbirds and starlings on staging areas prior to rice planting. To support the registration of this management tool and improve current baiting methodologies, NWRC scientists conducted tests with caged blackbirds to identify DRC-1339 dose-response curves and determine dietary toxicity of DRC-1339. They also evaluated non-target hazards of DRC-1339 in Louisiana, Missouri and Texas and completed a DRC-1339 confined rotational crop study. This and other studies indicate that hazards to non-target birds are minimal during DRC-1339 baiting operations. Research continues on developing new and improved DRC-1339 bait formulations and delivery methods that improve baiting effectiveness and comply with regulatory issues.

Use of Day-Glo® Fluorescent Marker to Monitor Blackbirds—NWRC scientists used a Day-glo paint pigment to aerially mass-mark more than 3.2 million blackbirds causing damage to rice in Missouri. Three different rice-field roosts containing from 700,000 to 2.2 million birds were sprayed

with different Day-glo colors on consecutive nights. Birds subsequently were collected during January and February 2006 in various rice-producing counties in Louisiana, Arkansas, and Missouri to determine the regional and migratory movements of birds after the rice-growing season. Ten percent of 3,282 blackbirds collected were marked. Collections continued during the following spring to determine the distribution of breeding male red-winged blackbirds in respect to the marking sites. This technique shows promise as an effective way of determining blackbird roost turnover, roost interchange, movement patterns, and distribution.

Groups Affected By This Problem:

- Rice producers
- Consumers of rice products
- Processors, manufacturers, suppliers and sellers of rice products
- Other crop farmers

Major Cooperators:

- Louisiana Rice Research Board
- Louisiana Rice Producers Association
- Louisiana Blackbird Committee
- USA Rice Federation
- Louisiana Rice Research Station (LSU)
- Delta Research Station (MU)
- Missouri Rice Research and Merchandising Council
- Gowan Company
- Syngenta Crop Protection

Selected Publications:

Avery, M. L., S. J. Werner, J. L. Cummings, J. S. Humphrey, M. P. Milleson, J. C. Carlson, T. M. Primus; M. J. Goodall. 2005. Caffeine for reducing bird damage to newly seeded rice. Crop Protection 24:651-657.

Cummings, J. L.; S. A. Shwiff; S. K. Tupper. 2005. Economic impacts of blackbirds on the rice industry. In: Nolte,D.L.; Fagerstone, K.A.; eds. Proceedings of the 11th Wildlife Damage Management Conference. 16-19 May 2005; Traverse City, MI. The Wildlife Damage Management Working Group of the Wildlife Society: 317-322.

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Resource Protection Through Avian Population Management

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National Wildlife Research Center Scientists Address Problems of Overabundant Bird Populations

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research organization devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and acceptable methods, tools, and techniques.

Researchers at NWRC's field station in Gainesville, FL, conduct research to resolve problems caused by vultures, crows, and other species of overabundant birds. This research facility is a uniquely designed 26-acre site with large outdoor flight pens and aviaries which allow bird research to be conducted throughout the year under natural environmental conditions.

As land-use patterns change and urban populations surge into previously uninhabited areas, wildlife conflicts inevitably increase. Of growing concern are problems associated with vultures and crows, species that have shown the capacity to readily adapt to residential settings. Additionally, populations of non-native species, such as feral pigeons and monk parakeets, continue to grow with increasing detrimental impacts to human health and safety.

Major Research Accomplishments:

- WS initiated a satellite telemetry study to collect information on flight patterns and altitudes of vultures. The information was used to develop management strategies for reducing hazards to aircraft at military air bases.
- WS provided key research findings for the development and registration of chemical reproductive inhibitors to reduce populations of nonnative feral pigeons and monk parakeets.
- WS demonstrated the utility of artificial crow effigies as components of integrated management strategies for dispersal of nuisance winter urban crow roosts.

Applying Science and Expertise to Wildlife Challenges

Vulture Management at Military Airbases—NWRC scientists are documenting vulture movements and resource use at military installations in order to reduce hazards to aircraft. At a site in South Carolina, 16 vultures have been trapped and equipped with satellite transmitters that provide hourly updates on the birds' location, altitude, and speed. Dozens of other vultures have been trapped and equipped with wing tags for visual identification. Key roost sites will be identified for dispersal, and the birds' activities subsequent to dispersal will be monitored to determine effectiveness of the action. At an Air Force site in south Florida, vulture roosts and feeding sites have been identified and a vulture management plan has been developed to increase air traffic safety.

Management Methods for Urban Crow Roosts—NWRC scientists are collaborating with WS operational staff and University researchers to develop strategies for managing large crow roosts in urban areas throughout the United States. One such roost of approximately 30,000 crows in the Lancaster, PA, area is the focus of current investigations. NWRC scientists are documenting responses of crows to artificial effigies as a means of roost dispersal. They also are evaluating the effectiveness of community-based efforts to rid areas of nuisance winter crow roosts through coordinated applications of nonlethal methods.

Reproductive Control of Nonnative Avian Species— Monk parakeet populations are growing exponentially in certain areas of the United States. The species, which is native to South America, builds large stick nests that are often located in electric utility facilities. As a result, frequent short circuits and costly power outages occur.

To help retard the growth of parakeet populations, NWRC scientists are collaborating with utility companies to develop a contraceptive bait. The active ingredient is

a cholesterol-inhibiting compound called diazacon. To date, nesting studies with captive parakeets and a field trial in south Florida have confirmed the potential utility of diazacon for parakeet reproductive control. Additional field studies are planned.

Through collaborations with private industry, NWRC scientists are developing chemicals to inhibit reproduction in feral pigeons and monk parakeets. Information developed by NWRC scientists through feeding trials and captive nesting studies with pigeons has been submitted to the U.S. Environmental Protection Agency in support of a Federal registration for a bait containing nicarbazin as the active ingredient.

Groups Affected By These Problems:

- Airports
- Airlines
- Air travelers
- Homeowners
- Business owners
- City managers
- Military installations
- Electric utility companies
- Broadcast and communication tower owners and operators

Major Cooperators:

- Wildlife Services Operations in Florida, South Carolina, Pennsylvania, Virginia
- Florida Power and Light Company
- Innolytics, LLC
- Pennsylvania State University

Selected Publications:

Pruett-Jones, S. J. R. Newman, C.M. Newman, M.L. Avery, and J.R. Lindsay. 2007. Population viability analysis of monk parakeets in the United States and examination of alternative management strategies. Human-Wildlife Conflicts 1:35-44.

Avery, M. L., J. R. Lindsay, J. R. Newman, S. Pruett-Jones, and E. A. Tillman. 2006. Reducing monk parakeet impacts to electric utility facilities in south Florida. Pages 125-136 in C. J. Feare and D. P. Cowan (eds). Advances in Vertebrate Pest Management, volume 4.

Avery, M. L., and E. A. Tillman. 2005. Alien birds in North America-challenges for wildlife managers. Proceedings of the Wildlife Damage Management Conference 11:82-89.

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Surveillance, Monitoring and Research on Emerging Zoonotic Diseases

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National Wildlife Research Center Scientists Monitor and Assess the Roles of Wildlife in the Transmission and Spread of Emerging Infectious Diseases

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research organization devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and acceptable methods, tools, and techniques.

Considerable concern exists around the world about recent emerging infectious diseases. Seventy-five percent of these emerging infectious diseases are zoonotic, meaning they are naturally transmitted between wildlife species and humans. Some zoonotic diseases carried by wildlife also can be transmitted to economically important domestic animals, such as West Nile virus (WNV) to horses, and avian influenza (AI) to poultry. Thus, wildlife populations often play a key role in many diseases that directly impact humans and agriculture. NWRC is at the forefront in the monitoring, surveillance and research of many of these diseases.

AI viruses are found naturally in waterfowl and other wild bird species. There are 144 known subtypes of AI but few of these subtypes cause serious disease in birds. However, mutation of the virus can lead to infection of new wildlife species, domestic livestock (primarily poultry), and humans. These changes can result in AI strains that are highly pathogenic. Recently, highly pathogenic avian influenza (HPAI) has spread from Asia across the Eastern Hemisphere and has caused considerable mortality in domestic poultry, as well as some human deaths. The rapid geographic expansion of HPAI has prompted early detection and monitoring plans in the United States and increased research into how the virus may be spread through wildlife populations.

Another disease of concern is WNV which first appeared in North America in 1999 and has since spread across the United States. The virus is spread through the bite of a mosquito. Birds are the primary host, but mammals, including humans, can also become infected. WNV causes illness and mortality in wild birds, some wild mammals, domestic horses and humans. For example, 2,947 people and 604 horses in Colorado were infected by WNV in 2003; 622 people were hospitalized and 63 people died, costing $22.4 million in Colorado for that year alone. WNV continues to be a pathogen of concern to human health. Study of the ecology of WNV can also help the United States prepare for potential future disease introductions.

Major Research Accomplishments:

- WS developed sampling and laboratory methodologies and processed approximately 50,000 environmental samples in support of the national avian influenza monitoring effort.
- WS conducted research on the roles of wildlife in harboring and transmitting avian influenza to domestic animals and humans.
- WS is developing large-scale spatial risk assessment models to predict routes of introduction and spread of avian influenza in the United States.
- WS evaluated the role of wildlife as hosts for West Nile virus.
- WS continues to develop early-warning surveillance systems for predicting West Nile virus activity.

Applying Science and Expertise to Wildlife Challenges

Monitoring Highly-pathogenic H5N1 Avian Influenza in the United States–One potential route for introduction of HPAI into the United States includes migration of infected wild birds, including ducks, geese and shorebirds. Some waterfowl species may be only mildly affected by HPAI which makes them ideal dispersers of the virus over long distances. As part of the U.S. Interagency Strategic Plan for the Early Detection of Highly Pathogenic H5N1 Avian Influenza in Wild Migratory Birds, the NWRC was responsible for analyzing more than 50,000 fecal samples collected from wild birds. NWRC scientists also convened a committee of scientists to design a nation-wide monitoring program for the collection of environmental samples (both fecal and water), developed field sampling methods and guidelines, tested and evaluated various methods for collecting water samples from areas actively used by waterfowl, and developed laboratory assays to detect AI in fecal samples.

Potential Transmission and Spread of Avian Influenza from Waterfowl to Agriculture and Human Populations—In collaboration with other scientists, NWRC scientists are developing risk assessment models to identify potential routes of introduction and subsequent spread of AI by waterfowl in the United States. These models couple spatially explicit risk assessment models with field and laboratory data from AI samples collected from wild birds, band recovery data from waterfowl, the distribution of poultry operations, and genetic sequencing of detected AI subtypes in collected samples. Coupling the genetic information with band recovery data provides information about

migratory patterns and gives insight on where birds exposed to specific AI virus genotypes originated, where they moved to, and how they may further spread AI by mixing with other migratory populations. This allows scientists to identify areas where highly pathogenic strains of AI may be introduced into the United States and where they may subsequently spread in relation to domestic poultry operations and human populations.

Role of Feral Pigs and Wildlife in the Transmission and Spread of Avian Influenza—NWRC scientists are examining whether feral pigs, in association with natural wildlife reservoirs, such as waterfowl, pose risks for the development of virulent AI strains. Other avian and mammalian wildlife species, such as raccoons, may also carry and transmit AI from wildlife systems to agricultural and human systems. Because little is known about AI in other wildlife species, NWRC scientists have begun studies to determine whether wildlife species act as hosts for AI, whether they can be infected from water sources contaminated with AI by infected waterfowl, and whether they can transmit the virus to other wildlife species, livestock or poultry.

Development of New Methods to Monitor Avian Influenza in the Environment—Although AI can survive for extended periods in water (30-200 days), dilution of the virus in water beyond detectable limits may prevent the detection of the virus using current sampling methods. One alternative for sampling water is to use aquatic organisms, such as freshwater mollusks (mussels and clams), that naturally concentrate virus from the surrounding water. Mollusks accumulate a variety of viruses and can concentrate some virus 100-fold from the surrounding water in their tissues. NWRC scientists are investigating whether freshwater mollusks can concentrate AI virus from surrounding water and be a useful tool for monitoring the presence of AI in water. In addition, NWRC scientists are developing more sensitive laboratory assays to detect AI in water, fecal samples and tissues. These efforts, if successful, will significantly reduce field surveillance costs and allow for more accurate and thorough risk assessments.

Surveillance Studies for West Nile Virus Activity in a Variety of Hosts—Collaborative studies on the host range and exposure rates of WNV continue to be performed in a variety of species across the United States. These studies include evaluating: 1) different wild bird species as competent hosts for WNV, 2) the role of avian populations in maintenance of WNV, 3) the exposure rates to WNV in a variety of mammal species, and 4) tree squirrels as wildlife hosts for WNV, as well as indicators of local prevalence of WNV. Among mammal species, prevalence of WNV antibodies ranged from 0% to 50.0%, with tree squirrels (Sciurus spp.) exhibiting high seroprevalence rates (49.1%). Experimental infections of tree squirrels indicated that they could serve as amplifying hosts in nature for WNV and could contribute to WNV transmission. Thus, squirrels may be good indicator species of WNV activity in an area. Sampling squirrels during the winter months may allow for accurate predictions of where WNV will be active the following year.

Cliff Swallows as Early Indicators of West Nile Virus—Identifying and predicting the intensity of WNV activity in certain areas is crucial to the planning of disease control activities. NWRC researchers have identified a promising surveillance system in nesting cliff swallows. WNV positive ectoparasites (swallow bugs) found in swallow nests are capable of over-wintering in the nests and can be used to indicate possible sources of future viral activity. In fact, researchers identified WNV infection in cliff swallow nestlings five weeks prior to the first human infections. The role of ectoparasites in the transmission cycle of WNV is currently being examined more closely in laboratory and field studies. Sampling cliff swallow nests is economical because swallows nest on bridges over water and the nests are easily accessible. Testing for WNV in bugs extracted from nests during the winter allows for the easy prediction of disease activity the following spring. Using this system, NWRC provides surveillance data to public health officials that aids in the targeting of areas for pesticide application to control mosquitoes.

Groups Affected By These Problems:

- Wildlife and natural resource managers
- U.S. citizens
- Livestock and poultry producers
- Farmers
- Consumers
- Public health organizations and hospitals
- Federal, State and Local governments

Major Cooperators:

- USDA/APHIS/Wildlife Services
- USDA/APHIS/Veterinary Services
- DOI/USGS/Biological Resources Division
- Colorado State University
- State Departments of Public Health
- Mississippi State University
- Berryman Institute

Selected Publications:

Clark, L.; Hall, J. S. 2006. Avian influenza in wild birds: status as reservoirs and risks posed to humans and agriculture. Ornithological Monographs 60:3-29.

Clark, L.; Hall, J. S.; McLean, R. G.; Dunbar, M.; Klenk, K.; Bowen, R; Smeraski, C. A. 2006. Susceptibility of greater sage-grouse to experimental infection with West Nile virus. Journal of Wildlife Diseases 42:14-22.

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Root, J.J.; Oesterle, P.; Nemeth, N.; Klenk, K.; Gould, D. H.; McLean, R.G., Clark, L.; Hall, J. S. 2006. Experimental infection of fox squirrels (Sciurus niger) with West Nile virus. American Journal of Tropical Medicine and Hygiene 75:697-701.

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Santaella, J.; McLean, R.; Hall, J. S.; Gill, J. S.; Bowen, R. A.; Hadow, H. H.; Clark, L. 2005. West Nile virus serosurveillance in Iowa white-tailed deer (1999-2003). American Journal of Tropical Medicine & Hygiene 73:1038-1042.

Sullivan, H.; Linz, G.; Clark, L.; Salman, M. 2006. West Nile virus antibody response in Red-winged blackbirds (Agelaius phoeniceus) from North Dakota (2003-2004). Vector-borne and Zoonotic Disease 6(3):305-309.

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Development of Nicarbazin for Application as an Infertility Agent

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National Wildlife Research Center Scientists Explore Mechanisms to Reduce Canada Goose and Pigeon Fertility

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research organization devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and acceptable methods, tools, and techniques.

As goose populations and urban areas expand and overlap, Canada geese are often considered a nuisance and potential health and safety problem (e.g., colliding with aircraft, fouling land and water, potential source of disease). In addition, goose-related damage to crops and rangelands causes the loss of millions of dollars in agricultural production. Pigeons also pose nuisance and potential health problems, and their feces can cause corrosion and structural damage to buildings.

Strong public support exists for the development and use of nonlethal methods to manage the flock size of Canada geese and pigeons that reside near or on airports, golf courses, industrial parks, government sites, and city parks. NWRC scientists are testing nicarbazin as an effective nonlethal tool to control reproductive fertility in overabundant bird populations, such as Canada geese and pigeons.

Major Research Accomplishments:

- WS demonstrated that the chemical nicarbazin is effective as a reproductive inhibitor for Canada geese and pigeons.

Applying Science and Expertise to Wildlife Challenges

Efficacy of Nicarbazin—Research to develop nicarbazin as a contraceptive agent has shown great promise in reducing the reproductive success of resident Canada geese and pigeons. A multiple-year study in Colorado showed that use of nicarbazin in areas where Canada geese were nesting effectively reduced the number of eggs that hatched by 53 percent. In 2005-2006, captive breeding studies with pigeons also showed nicarbazin was effective in reducing egg hatchability by 59 percent.

Palatability of Nicarbazin Bait—One of the challenges associated with the development of an oral contraceptive bait for Canada geese was making the bait tasty and appealing for the birds. Experiments with captive Canada geese demonstrated that a product called OvoControl-G™ (developed by Innolytics LLC) is a highly palatable bait.

OvoControl-G™ is a semi-soft, wheat-based bread bait that contains 2500 ppm nicarbazin and resembles a kernel of corn in shape and color. Canada geese in pens at NWRC consumed enough OvoControl-G™ bait to provide a contraceptive dose of nicarbazin. As a result, OvoControl-G™ was selected as suitable bait for field efficacy studies that were used to support registration of nicarbazin by the Environmental Protection Agency (EPA) as a reproductive control agent for Canada geese. A similar bait, OvoControl-P, was developed for pigeons. A registration package has been submitted to the EPA for registration of OvoControl-P as a reproductive inhibitor for pigeons.

The Field Efficacy Study—A field study of the effectiveness of nicarbazin in reducing the hatchability of Canada goose eggs was conducted during spring 2004 in Oregon. Hatchability at sites where nicarbazin-treated bait was consumed by geese was approximately 51% lower than hatchability at sites where non-treated bait was consumed. Data from this study were submitted to support an EPA registration of nicarbazin as a reproductive inhibitor for Canada geese. In November 2005, OvoControl-G

was registered with the EPA for control of resident Canada geese and is now commercially available from Innolytics, Inc. NWRC received an "Outstanding Technology Development" award from the Federal Laboratory Consortium for its role in the development of this new technology.

Groups Affected by These Problems:

- Airports and patrons
- Municipalities
- Homeowners
- Homeowners' associations and property managers
- Citizens using urban recreational facilities
- Golf courses and patrons
- Farmers
- Livestock producers
- Natural resource managers

Major Cooperators:

- Innolytics, LLC
- Wildlife Services Operations

Selected Publications:

Bynum, K.S., J.D. Eiseman, G.C. Weaver, C.A. Yoder, K.A. Fagerstone, and L. Miller. 2007. Nicarbazin OvoControl G bait reduces hatchability of eggs laid by resident Canada geese in Oregon. Journal of Wildlife Management 71:135-143.

Yoder, C.A., J.K. Graham, L.A. Miller, K.S. Bynum, J.J. Johnston, and M.J. Goodall. 2006. Evaluation of nicarbazin as a potential waterfowl contraceptive using mallards as a model. Poultry Science 85:1275-1284.

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Bynum, K.S., C.A. Yoder, J.D. Eisemann, K.A. Crane, and L.A. Miller. 2005. Development of nicarbazin as a reproductive inhibitor for Canada geese. Proceedings of the Wildlife Damage Management Meeting 11:179-189.

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Development of Reproductive Control Methods for Overabundant Birds and Mammals

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National Wildlife Research Center Scientists Study Wildlife Contraception

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research facility devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and acceptable methods, tools, and techniques.

Research on the reproductive management of various avian and mammalian species that cause damage or threaten public health and safety is a high priority for WS. The severity of human-wildlife conflicts often is directly related to wildlife population density: many problems are exacerbated as wildlife populations become larger. In many urban and suburban settings, for example, overabundant deer create safety hazards for motorists, consume ornamental shrubs, harbor and transmit diseases and parasites (e.g., Lyme-disease-bearing ticks), and degrade habitat quality in public parks and other locations. Rodents also carry a variety of diseases (e.g., plague, hantavirus), and they damage rangelands and crops, causing the loss of millions of dollars in agricultural production. More than four million feral hogs now occur in at least 28 states, where they cause serious ecological damage as well as serving as a reservoir for pseudorabies and brucellosis. Overabundant feral horses in several western states continue to create ecological and political problems. Tens of millions of feral cats and dogs in the United States harass and kill wildlife and livestock, and create public health nuisances through their bites, waste, and transmission of diseases and parasites. In addition, when populations of native predators such as coyotes are locally overabundant, they are sometimes responsible for severe losses by livestock producers.

The goal of NWRC's wildlife contraceptive research is to develop and field test economical and effective agents to suppress reproductive fertility in local populations of selected species that are causing conflicts. Wildlife contraceptives can be used as an additional tool for the integrated management of local, overabundant wildlife species.

Major Research Accomplishments:

- WS developed a new adjuvant (AdjuVac™), which facilitated the creation of a new, GnRH-based, single-injection immunocontraceptive vaccine called GonaCon™.
- WS conducted numerous studies on the safety, efficacy, and practicality of the GnRH vaccine on several wildlife species including California ground squirrels, Norway rats, feral cats and dogs, baboons, burros, swine, horses, and deer.
- WS is conducting several laboratory and field studies to evaluate the use of diazacon as a mammalian and avian contraceptive.

Applying Science and Expertise to Wildlife Challenges

Wildlife Contraception—NWRC researchers have successfully tested a single-injection, GnRH (gonadotropin-releasing hormone), immunocontraceptive vaccine (called GonaCon™) on free-ranging California ground squirrels, captive Norway rats, feral cats and dogs, domestic and feral swine, wildhorses, elk, and white-tailed deer. Temporary infertility was achieved in all species tested. Ongoing field studies in Maryland and New Jersey are evaluating the safety and efficacy of this vaccine, as required by the U.S. Environmental Protection Agency.

Development of the single-injection form of the GonaCon™ vaccine was made possible by the creation at NWRC of a new adjuvant called AdjuVac™. An adjuvant is an immunological agent that is added to a vaccine to improve the immune response. The GonaCon™ vaccine, which incorporates the AdjuVac™ adjuvant, could prove useful as part of an integrated management plan for overabundant wildlife species.

Scientists at NWRC are also developing safe, effective, and economical infertility agents for other wildlife species, including prairie dogs, Canada geese, and other mammals and birds. Ongoing studies are evaluating several contraceptive agents, including diazacon and nicarbazin in birds, and a range of compounds in mammals. In addition, NWRC scientists are testing the stability and viability of an oral vaccine in a variety of formulations to find the best

method for delivering infertility agents to free-ranging animals.

Field Studies—NWRC has received an Investigational New Animal Drug (INAD) permit for GnRH injectable vaccines. This permit allows NWRC researchers and their collaborators to ship and test the vaccines on both captive and free-ranging animals. Tests of the GnRH vaccine are ongoing in several states and countries, involving a wide range of wildlife and feral species.

Groups Affected by These Problems:

- Urban and suburban residents
- Airports, airlines, airline passengers
- Motorists, pedestrians
- Farmers
- Ranchers/Livestock producers
- Natural resource managers
- Landscapers
- Pet Owners

Major Cooperators:

- Cornell University
- Pennsylvania State University
- University of Florida
- Colorado State University
- University of Sao Paulo, Brazil
- Idaho Department of Fish and Game
- Florida Department of Agriculture and Consumer Services
- U.S. Army
- Wildlife Services Operations personnel
- University of Pittsburgh

Selected Publications:

Killian, G., L. Miller, J. Rhyan, and H. Doten. 2006. Immunocontraception of Florida feral swine with a single-dose GnRH vaccine. American Journal of Reproductive Immunology 55:378-384.

Bynum, K. S., C. A. Yoder, J. D. Eisemann, J. J. Johnston, and L. A. Miller. 2005. Development of nicarbazin as a reproductive inhibitor for resident Canada geese. Proceedings of the Wildlife Damage Management Conference 11:179-189.

Fagerstone, K. A., H. P. Tietjen, J. F. Glahn, G. L. Shembeck, and J. B. Bourassa. 2005. Black-tailed prairie dog colony dynamics in South Dakota over a 10-year period. Proceedings of the Wildlife Damage Management Conference 11:323-336.

Griffen, B., H. Baker, E. Welles, L. A. Miller, and K. A. Fagerstone. 2005. Response of dogs to a GnRH-KLH conjugate contraceptive vaccine adjuvanted with Adjuvac®. Pages 185-186 in Proceedings of the 2004 ACCD International Symposium on Nonsurgical Methods for Pet Population Control. Alliance for Contraception in Cats and Dogs, Denver, Colorado.

Killian, G., D. Wagner, and L. Miller. 2005. Observations on the use of the GnRH vaccine GonaCon in male white-tailed deer (*Odocoileus virginianus*). Proceedings of the Wildlife Damage Management Conference 11:256-263.

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Levy, J. K., Miller, L. A., Crawford, P. C., Ritchey, J. W., Ross, M. K., and Fagerstone, K. A. 2004. GnRH immunocontraception of male cats. Theriogenology 62:1116-1130.

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Yoder, C. A., Andelt, W. F., Miller, L. A., Johnston, J. J., and Goodall, M. J. 2004. Effectiveness of twenty, twenty-five diazacholesterol, avian gonadotropin-releasing hormone, and chicken riboflavin carrier protein for inhibiting reproduction in coturnix quail. Poultry Science 83:234-244.

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Ecology, Behavior, and Management Methods for Predators to Protect Livestock and Wildlife

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National Wildlife Research Center Scientists Study Predation Behavior and Ecology

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research facility devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and acceptable methods, tools, and techniques. NWRC's field station in Logan, UT, is the leading coyote ecology research complex in the world.

Data on predator population dynamics, ecology, and behavior are necessary to understand predation patterns on livestock, game species, and threatened and endangered species. These data are also needed for effective depredation management, but significant gaps of knowledge exist with regard to predator-prey, predator-livestock, and predator-predator relationships. NWRC scientists use a multi-disciplinary approach to study interactions among predators, and the impact of predators and predator removal on ecosystems and wildlife population dynamics. Results from their studies are fundamental to selective predator management. The information gathered will also be used to guide WS' operational programs, and to provide necessary information in the National Environmental Policy Act (NEPA) process.

Major Research Accomplishments:

- WS demonstrated that coyotes can exert significant negative impacts on smaller predators (swift fox, kit fox) and may decimate populations under appropriate conditions.
- WS examined the impacts not only of predators on livestock, but of predators on each other.
- WS showed that wolves regularly traveled out of reserves and used areas frequented by livestock.

Applying Science and Expertise to Wildlife Challenges

Understanding Predator-Prey Systems— Through field studies, knowledge of the interactions between predators and prey (livestock, native prey, or other predators) will aid in regulatory compliance for WS, particularly with regard to NEPA and Endangered Species Act regulations. At the NWRC field station in Logan, UT, current studies include determining the population ecology and evaluating survey methods for swift foxes; examining interactions between coyotes and kit foxes; investigating swift foxes as an indicator species of ecosystem health; determining interactions among wolves, coyotes, and mule deer and their influence in the abundances of these species; examining the interactions between wolves, coyotes, and pronghorn; and investigating the predation patterns of jaguars on livestock and native prey species.

Basic Predator Biology and Management Methods—NWRC studies investigating prey cycles and nutrition are revealing patterns in coyote population regulation and are focusing on the basic causes of coyote depredation. Other studies are examining the abilities of coyotes to avoid capture and other management techniques. Results are aiding in the development of new management techniques.

A Manual on Methods for Protecting Livestock from Predators—In 2005, NWRC scientists published "Lines of defense: coping with predators in the Rocky Mountain region." This document describes the latest advances in methods and strategies for protecting livestock from predation. The document provides information in a useful and practical format that can be used by producers and scientists alike.

Groups Affected By These Problems:

- Livestock producers
- Wildlife managers
- Environmental organizations
- Land management agencies

Major Cooperators:

- Utah State University
- The Berryman Institute
- U.S. Army

Selected Publications:

Blejwas, K. M., C. L. Williams, G. T. Shin, D. R. McCullough, and M. M. Jaeger. 2006. Salivary DNA evidence convicts breeding male coyotes of killing sheep. Journal of Wildlife Management 70: 1087-1093.

Chavez, A. S., and E. M. Gese. 2006. Landscape use and movements of wolves in relation to livestock in a wildland-agriculture matrix. Journal of Wildlife Management 70:1079-1086.

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United States Department of Agriculture

Animal and Plant Health Inspection Service

FY 2006

Improved Technologies and Nonlethal Techniques for Managing Predation

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National Wildlife Research Center Scientists Explore Innovative Ways to Protect Livestock from Predators

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research facility devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and acceptable methods, tools, and techniques.

The need for acceptable and effective predator management tools to reduce livestock losses and protect public safety is a high priority for WS. Livestock predation costs producers approximately $93 million each year. Concerns for public health and safety, as well as animal welfare, have also pressured wildlife managers to seek immediate solutions when predators cause conflicts. Research conducted by scientists at NWRC's field station in Logan, UT, is focused on finding alternative, nonlethal tools and techniques to prevent predatory behavior through the use of disruptive (frightening) and aversive (behaviorally conditioning) stimuli. In addition, NWRC researchers are developing improved methods for capturing predators and monitoring their behaviors and movements.

Major Research Accomplishments:

- WS examined the use of aversive conditioning for repelling bears from campgrounds.
- WS designed, fabricated, and evaluated unique electronic animal repellent systems to prevent carnivore predation on livestock.
- WS promoted the development of real-time, satellite-driven animal and capture-device monitor prototypes.
- WS developed and tested new capture systems and site monitor technologies for wildlife.

Applying Science and Expertise to Wildlife Challenges

Capture Devices and Attractants— Capture technology has been largely reliant on tools and materials that were developed hundreds of years ago. While effective, some of these capture methods have raised concerns about operating efficiency and animal welfare. In response, NWRC scientists have developed and tested new devices and attractants in order to more selectively and efficiently capture specific species. For instance, a recent study examined the capture efficiency, selectivity, and injuries caused by cage traps, Collarums™, padded jawed traps, and a new throw-arm cable restraint invented by WS employees.

As world leaders in animal capture technology, NWRC scientists are also working closely with state fish and wildlife agencies, as well as with countries in the European Union, to develop and test new attractants and capture devices for canids, such as wolves, coyotes, and foxes.

Aversive Conditioning Devices—Research is being conducted to develop aversive conditioning devices to keep predators away from livestock. For example, predator-activated conditioning collars, much like those used to train dogs, have been field tested on wolves in an effort to prevent livestock-attack behaviors. Currently, one research study is investigating the use of food conditioning to repel bears from campgrounds and another is examining a new approach, electrified fladry, which combines an animal's fear of a novel stimulus with conditioning from an unpleasant electric shock. In an initial study, NWRC scientist tested electrified fladry on 36 wolves in 10 groups. Eight groups of wolves crossed the normal fladry barrier, but only 2 crossed the electrified fladry.

Monitoring Capture Sites—The NWRC field station in Logan, UT, is assisting with the distribution, operation, and evaluation of trap monitors for use by WS operations. The devices, which can be used with any type of trap, consist of small radio transmitters that emit unique pulse rates when animals are captured. Preliminary evaluations indicate that trap monitors can improve the Agency's efficiency by eliminating unnecessary travel to and from trap sites.

Groups Affected by This Problem:

- Livestock producers
- Private citizens

Major Cooperators:

- Utah Division of Wildlife Resources
- Montana Fish, Wildlife, and Parks
- Utah State University
- Welder Wildlife Foundation

Selected Publications:

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Reducing Wildlife Damage to Forested and Riparian Ecosystems

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National Wildlife Research Center Scientists Develop Methods to Reduce Timber Damage

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research facility devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and acceptable methods, tools, and techniques. NWRC's field station in Olympia, WA, has the capacity to conduct research on most animals associated with forest resource damage. Damage to timber resources at the human-wildlife interface often occurs in a variety of environments, ranging from bottomland hardwood forests to upland conifer farms.

Wildlife impacts on forest resources can be extensive. For example, attempts to replace trees after a harvest or a fire can be complete failures because of foraging wildlife. Reforestation efforts are greatly hindered by bears, beavers, deer, elk, mice, mountain beavers, pocket gophers, porcupines, and voles cutting and gnawing on seedlings. Some of the same species that damage seedlings also damage and destroy established trees after canopy closure. Select species cause multiple impacts by their behavior and habits. For example, beavers are found in upland, lowland, and riparian habitats and they directly destroy trees by their foraging habits. Impounded water created by beaver damming activity floods and kills additional trees. Furthermore, altered water patterns caused by beaver damming erode roads and railways causing danger for human health and safety.

Developing nonlethal methods to manage wildlife damage is a priority in the ongoing research conducted at NWRC's Washington field station. Scientists are currently conducting research to develop alternatives to lethal control, including physical deterrents, repellents, frightening devices, habitat and behavior modification, and improved capture methods.

NWRC scientists are working with a variety of natural resource managers to address the most significant wildlife damage problems in forested areas. The research that NWRC is conducting is specifically targeted to find solutions to problems found in the Northwestern and Southeastern forests of the United States.

Major Research Accomplishments:

- WS evaluated efficacy of chlorophacinone as a toxicant for managing mountain beavers.
- WS evaluated the efficacy of hydrolyzed casein as a new repellent for rodents and ungulates.
- WS evaluated flavor aversion learning (FAL) for deterring ungulates from select tree species.
- WS assessed beaver demographics in high use areas of the southeastern United States.
- WS determined the demographics and territorial behaviors of mountain beavers in the Pacific Northwest.

Applying Science and Expertise to Wildlife Challenges

A New Tool for Managing Mountain Beavers—The mountain beaver (Aplodontia rufa) is a rodent species endemic to the Pacific Northwest and northern coastal California. Unlike a true beaver, it has a short tail and is not well adapted to aquatic life but lives underground and is seldom seen. This herbivore is managed as a pest species because of the impact it has on newly planted Douglas-fir (*Pseudotsuga menziesii*) seedlings and Douglas-fir trees 10-15 years old. Attempts to manage mountain beavers through repellents, barriers, and trapping are costly and not always productive. Results from a series of studies at the Washington field station concluded that chlorophacinone was an efficacious and environmentally safe toxicant with potential as a tool to control mountain beavers. Consequently, special local needs (SLN) labels were recently approved in Washington and Oregon for the use of Rozol™ (active ingredient chlorophacinone) as an additional tool to manage mountain beavers. Results from additional studies recommend integrating this tool with traditional trapping to increase forest health and reduce economic impacts.

Developing and Testing Repellents to Protect Forest Resources—Use of repellents for protecting trees can be cost prohibitive and results are generally short term. Thus, the need exists for a cost effective and long lasting repellent for application in forest management. NWRC studies are evaluating the effects of hydrolyzed casein as a repellent for rodents and ungulates. Initial results showed a simple repellent made from glue and hydrolyzed casein may offer considerable browse protection from deer when alternative forage is available. NWRC scientists also concluded that avoidance of foods treated with animal-based proteins, such as hydrolyzed casein, was mediated by changes in palatability, not fear of predation. Other studies are working to identify genetically-controlled chemical characteristics which promote herbivore avoidance of select tree species.

Groups Affected By These Problems:

- Commercial timber producers
- Gardeners/Landscapers
- Homeowners
- Natural resource managers
- Noncommercial forest land owners
- Orchard managers
- State departments of transportation

Major Cooperators:

- Mississippi State University
- Oregon Forest Industries Council
- Oregon Department of Forestry
- Tres Rios, City of Phoenix
- Washington Forest Protection Association
- Washington Department of Natural Resources
- USDA Forest Service
- Utah State University

Dietary Behaviors—Most problems associated with wildlife occur because of their foraging activities. NWRC researchers are working to determine how select wildlife species respond to chemical components in foods. Forestry practices, such as thinning or fertilizing, influence plant chemistry, with one consequence being the increase in sugar to terpene ratio, making trees more desirable as a food to many wildlife species. Conversely, pruning trees decreases their likelihood of being targeted as food. Ongoing collaborative efforts will determine which traits can be selected to produce less palatable trees. Concurrently, ongoing studies suggest that a deer's nutritional status impacts its willingness to ingest foods containing high terpene levels. Understanding these and other mechanisms that control dietary behaviors aid in the development of management strategies for decreasing damage and help create models for predicting where damage is most likely to occur.

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Development and Assessment of Methods and Strategies to Monitor and Manage Mammalian Invasive Species with Special Emphasis on Rodents

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National Wildlife Research Center Scientists Assess and Develop Methods to Manage or Eradicate Introduced and Invasive Mammals

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research organization devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and acceptable methods, tools, and techniques.

The National Invasive Species Council has documented the serious threat to agriculture, property, natural resources, and human health and safety in the U.S posed by invasive or introduced plants, invertebrates, disease agents, and vertebrates. Pimentel and others (2000) estimated that invasive species result in at least $138 million per year in losses, damage, and control. About 300 species of invasive vertebrates have been accidentally or purposefully introduced into the U.S., including about 20 species of mammals. These include omnivores (rats, feral pigs), predators (mongoose, foxes, feral dogs and cats), and herbivores (feral livestock, non-native deer).

WS has a long history of involvement in invasive species management, not only on the mainland U.S., but in Hawaii, the Caribbean, South America, Africa, Indonesia and the Philippines. Research continues to improve methods and strategies to 1) prevent introductions, 2) detect new introductions, 3) eradicate introductions, and 4) support sustained control for well-established invasive species where eradication is not feasible.

Major Research Accomplishments:

- WS organized an invasive species session at the 11th Wildlife Damage Management Conference in Traverse City, Michigan, in March 2005.
- WS identified effective attractants and rodenticides for rats, mice, and nutria.
- WS identified an effective rodenticide bait for use in eradicating the invasive Gambian giant pouched rat in Florida.

Applying Science and Expertise to Wildlife Challenges

Developing Methods to Eradicate Gambian giant pouched rats from the Florida Keys—Introduced Gambian rats have become established on Grassy Key, an island in the Florida Keys. If they reach the mainland, they could cause significant damage to agriculture and natural resources. Studies have been conducted to identify an effective rodenticide for use in eradicating the rats. An eradication strategy has been designed and will be implemented in 2007. Several state, county, and Federal agencies are cooperating in this effort. A grid of bait stations containing a zinc phosphide rodenticide bait will be used. Monitoring will continue to assure that the rats have been successfully eradicated.

Developing Effective Attractants for Norway Rats—NWRC scientists are studying potential attractants for use in baiting, capturing and monitoring Norway rats. Effective attractants will help in the eradication of rats on islands to which they have been accidentally introduced. Of the attractants tested, almond, ginger, and lemon extracts have proved the most effective.

Identifying Effective Commercial Rodenticides for Commensal Rodents—Many commercial rodenticides are registered for commensal rodents (rats and mice living in close association with humans), but these are not all equally effective across rodent species and settings. NWRC scientists have assessed the efficacy of 12 rodenticide formulations with wild Norway rats and wild house mice; some of these were anticoagulants and some were acute toxicants. Most were effective on Norway rats with a 3-day exposure, but relatively few were effective with house mice even with a 7-day exposure. These results suggest that new methods will need to be explored in order for the successful eradication of house mice from islands to which they have been accidentally introduced.

Developing Effective Lures for Nutria Control—NWRC scientists have conducted several studies with captive and free-ranging nutria in Louisiana to identify effective lures. Lures, also known as attractants, are needed to improve capture success and to aid in monitoring nutria populations during control efforts. Fertilized marsh plants have been shown to be especially attractive to nutria during winter months when forage is limited. Additionally, bio-chemicals produced by nutria (fur extractions, anal secretions, and urine) have been effective attractants.

Groups Affected By These Problems:

Urban citizens

- Farmers
- Livestock producers
- Natural resource managers
- Conservationists
- Military bases

Major Cooperators:

- U.S. Fish and Wildlife Service
- U.S. National Park Service
- U.S. Department of Defense
- Florida Wildlife Commission
- Louisiana Department of Wildlife and Fisheries
- Island Conservation, Inc.

Selected Publications:

Engeman, R., J. Woolard, N. Perry, G. Witmer, S. Hardin, L. Brashears, H. Smith, B. Muiznieks, and B. Constantin. 2006. Rapid assessment for a new invasive species threat: the case of the Gambian giant pouched rat in Florida. Wildlife Research 33:439-448.

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Methods and Strategies to Manage Invasive Species Impacts to Agriculture in Hawaii

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National Wildlife Research Center Scientists Develop Methods to Reduce Damage Caused by Invasive Species to Agriculture, Natural Resources, and Human Health and Safety

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research facility devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and acceptable methods, tools, and techniques. NWRC's field station in Hilo, HI, is ideally located to allow research biologists to develop methods needed to control invasive species damage to Hawaiian agricultural crops and native ecosystems, as well as other areas throughout the Pacific.

Major Research Accomplishments:

- WS continued to develop tools to manage invasive tree frogs. Over the past three years, NWRC's Hawaii Field Station has developed the registration data for the use of caffeine, citric acid, and hydrated lime to reduce invasive tree frog populations.
- WS obtained the data for the registration of aerial broadcast of rodenticides for use in conservation areas and to protect native ecosystems.

Oceanic islands like the Hawaiian chain are more susceptible to invasive species than mainland areas because islands have few predators or competitors, have a lot of air and sea traffic, and typically provide a favorable climate for many species. Further, native species on the islands have evolved in the absence of many introduced threats and usually respond poorly to invasive animals or disease.

Invasive species are the single greatest threat to Hawaii's agricultural economy and natural environment and to the health and lifestyle of Hawaii's people. Invasive vertebrate species cause millions worth of crop losses, the extinction of native species, the destruction of native forests, and the spread of disease, and also reduce the health and safety of residents. NWRC scientists at the Hilo, HI, field station are investigating a variety of methods to reduce damage caused by invasive species, such as rodents, Coqui frogs, brown treesnakes, mongoose and invasive birds.

Applying Science and Expertise to Wildlife Challenges

Alternative Baits—To manage rodent damage in a more ecologically sound manner, NWRC scientists are identifying and evaluating alternative rodenticide baits. As part of this process, NWRC scientists are compiling the necessary data to Federally register these baits. Field tests are being conducted on roof rats, a species that decimates native ecosystems as well as agricultural crops throughout the Pacific region. Preliminary results show that some rodenticides are not as effective for wild mice and rats.

Introduced Invasive Species—The negative impacts of introduced species on island ecosystems are severe. In Hawaii, a species of tree frog was recently introduced from the Caribbean. In addition to its propensity for reproducing quickly and its piercing loud nighttime call, the species eats the insects and snails that native forest birds rely on for survival and may have significant effects on forest dynamics. NWRC scientists are

studying ways to manage frog populations, determine the effects of frogs on native ecosystems, and minimize their effects on agriculture. Current efforts are focused on the development and testing of toxicants, such as citric acid, that can be sprayed on frogs. The effects of these pesticides on plants and non-target animals are also studied.

There is also a serious concern about the introduction of Indian mongoose to other mongoose-free locations in the Pacific area. NWRC scientists are identifying candidate bait substrates, lures, and/or attractants that would elicit a strong attraction response from mongooses in the field. Preliminary results show that food-based baits are more effective than animal- or food-scents. Fish-based food baits were the most effective. Findings could aid in optimizing current detection and capture strategies for mongoose or be used in the development of toxicant baits specific for mongoose.

Groups Affected By These Problems:

- Wildlife managers
- Farmers
- Horticulture industry
- Natural resource managers
- Macadamia nut producers

Major Cooperators:

- Hawaii Agriculture Research Center
- US Fish and Wildlife Service
- Hawaii Department of Land and Natural Resources
- Hawaii Department of Agriculture
- University of Hawaii
- Kamehameha Schools Bishop Estate
- Tropical Fruit Growers of Hawaii
- MacFarms of Hawaii

Selected Publications:

Pitt, W. C. and G. W. Witmer. 2006. Invasive predators: a synthesis of the past, present, and future. In A. Elewa (ed.). Predation in organisms- A Distinct Phenomenon. Springer Verlag

Beard, K. H., and W. C. Pitt. 2005. Potential consequences of the coqui frog invasion in Hawaii. Diversity and Distributions. 11:427-433.

Johnston, J. J.; Pitt, W. C.; Sugihara, R. T.; Eisemann, J. D.; Primus, T. M.; Holmes, M.; Crocker, J.; Hart, A. 2005. Probabilistic Risk Assessment For Birds, Snails and Slugs in Diphacinone Rodenticide Baited Areas on Hawaii. Journal of Environmental Toxicology and Chemistry 24:1557-1567.

United States Department of Agriculture

Animal and Plant Health Inspection Service

FY 2006

Development of Surveillance Strategies and Management Tools to Control Pseudorabies and Other Wildlife Diseases that Affect Humans and Livestock

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National Wildlife Research Center Scientists Provide Basic Ecological Information and Tools for Management of Wildlife Diseases that Affect Livestock and Humans

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research organization devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and acceptable methods, tools, and techniques.

As increased urbanization leads to a loss of traditional wildlife habitat, the potential for conflicts between people and wildlife increases. Such conflicts can take many forms, but recently the potential for the transmission of diseases among wildlife, livestock, and humans has received greater attention.

The high reproductive rate and adaptability of the feral hog has resulted in populations that have dramatically increased in size and distribution. This invasive animal now occurs in 32 states, where it causes a range of agricultural and environmental damage through depredation, rooting, and wallowing activities. Furthermore, feral hogs compete with native wildlife and livestock for habitats, are carriers of exotic and endemic diseases, and transmit parasites to livestock and humans.

One disease of particular concern to the commercial swine industry is pseudorabies virus, an infectious, often acute, herpesviral disease that infects the nervous system of livestock and wildlife. The disease poses a potential hazard to humans and a major hazard to the swine industry. Adult swine that recover from pseudorabies can develop latent infections and shed the virus indefinitely, complicating eradication efforts. Feral hogs have been found seropositive for pseudorabies in 11 states where they are believed to be a free-ranging reservoir for the disease.

Major Research Accomplishments:

- WS developed surveillance strategies that evaluated the potential or actual risk that pseudorabies and other diseases in feral hogs pose to Texas livestock.
- WS developed baiting strategies for delivery of pharmaceuticals to control wildlife diseases, including pseudorabies.
- WS developed physical methods to minimize the transmission of pseudorabies and other diseases between livestock and wildlife.
- WS developed surveillance strategies to evaluate the risks of other wildlife diseases important to humans and livestock.

Applying Science and Expertise to Wildlife Challenges

Serologic Survey of Feral Hogs in Texas—The pork industry spends millions of dollars each year to prevent and eradicate diseases from domestic swine. Pseudorabies (PRV), brucellosis, and classical swine fever (CSF) have been eradicated from the domestic swine; however, PRV and brucellosis are both present in feral hog populations. A fourth disease, porcine respiratory and reproductive syndrome (PRRS), is an emerging disease in domestic swine and has recently been found in feral hog populations.

NWRC scientists conduct studies to determine the magnitude of disease prevalence in feral hog populations and ascertain whether feral hogs pose a disease threat to domestic swine. Feral hogs from eastern and southern Texas were trapped and tested for economically important diseases. Results from approximately 340 blood samples showed the prevalence of PRV, brucellosis, CSF, and PRRS was 28, 13, 0, and 1%, respectively.

Feral Hog Interactions with Domestic Swine—The feral hog population in Texas is estimated between 1.5–2 million animals, and their distribution and abundance within the state is expanding. Feral hogs are known carriers of many diseases and their presence near domestic swine may pose a disease transmission threat. To determine the potential frequency of interaction between feral hogs and neighboring domestic swine, NWRC scientists monitored penned domestic sows using motion sensing cameras and quantifying feral hog tracks. Results showed feral hogs were attracted to the domestic swine and interacted with them on 49% of the nights.

Another study involving the tracking of GPS-collared feral hog movements showed similar results. Of the locations recorded, 82 (3%) were within the defined interaction zone with domestic swine. Thus, NWRC scientists concluded that feral hogs are a potential threat for disease transmission to domestic swine.

Electric Fencing to Inhibit Feral Hog Movements—Feral hogs are implicated in erosion damage, destruction of crops, and transmission of disease to domestic livestock. Development of a cost effective barrier system to restrict feral hog movement will help alleviate and prevent these problems.

NWRC scientists evaluated the effectiveness of three different electric-fence arrangements in a captive setting with naïve, wild-caught feral hogs. The effectiveness of the most promising fence design was then tested in a field setting with wild, free-ranging feral hogs. The most promising fence arrangement, two strands at 8 and 18 inches, reduced movement of adult feral hogs by 88% and all feral hogs, including piglets, by 64%. Electric fencing has the potential to reduce problems associated with feral hogs. It is not an infallible method, however, so integrated management techniques incorporating sustained hunting, trapping, and fencing should be used.

Groups Affected By These Problems:

- Wildlife and natural resource managers
- U.S. citizens and landowners
- Livestock producers and farmers
- Sporting organizations
- Consumers
- Meat processors

Major Cooperators:

- Caesar Kleberg Wildlife Research Institute
- King Ranch, Inc.
- Texas A&M Health Sciences Center
- Texas A&M University-Kingsville
- Texas Animal Health Commission
- Texas Parks and Wildlife Department
- USDA/Agricultural Research Service
- USDA/APHIS/Veterinary Services
- USDA/APHIS/Wildlife Services
- Welder Wildlife Foundation

Multiple Paternity In Feral Hogs—NWRC scientists are gaining insights into the mating behavior of feral hogs. DNA samples from free-ranging pregnant sows and embryos were collected and analyzed. Results showed multiple paternity (siring of offspring by >1 male) in 4 of 12 feral hog litters (~33%). With this high rate of promiscuity (~33% of sows bred by >1 boar), the transmission rates increase for diseases spread by direct contact (e.g., pseudorabies, brucellosis). Results of this study provide valuable information useful for planning feral hog management in relation to the rate of disease transmission.

Feral Hog Bait Acceptability—Few studies have evaluated oral delivery systems of pharmaceuticals (e.g., vaccines) to feral hogs. A recent NWRC study assessed the percentage of feral hogs and non-target animals that removed and consumed PIGOUT® fish-flavored baits intended for feral hogs. Of the 1,178 iophenoxic acid (IA)-marked baits that were distributed and monitored, 51% were taken by raccoons, 22% were taken by feral hogs, and 20% were taken by collared peccaries. PIGOUT® fish-flavored baits were successful in marking a substantial proportion of feral hogs; however, removal rates suggest the majority of the baits were taken by non-target species and, therefore, unsuitable for many pharmaceutical applications in their current form. Other bait studies have shown that when targeting feral hogs, fish-flavored baits may be most appropriate when non-targets include herbivores, and that vegetable-flavored baits may be most appropriate when non-targets include omnivores and carnivores. Future research seeks to identify hog-specific chemical attractants for incorporation into baits.

Movements and Habitat Use of Nilgai Antelope in Southern Texas—The nilgai antelope was successfully introduced into South Texas in 1941 in an effort to occupy an ecological role intermediate between native wildlife and livestock. Nilgai now range freely throughout much of coastal south Texas, and current statewide estimates exceed 30,000 individuals. Nilgai are beneficial because they are hunted recreationally and harvested commercially for venison. Negative aspects of nilgai populations are damage to fences and competition for forage with deer and cattle. Anecdotal reports from landowners suggested that nilgai move long distances and their home ranges may encompass properties of multiple landowners. Such movement patterns could make nilgai difficult to manage. To address these issues, NWRC scientists are investigating nilgai home range size and movement patterns in relation to habitat characteristics, hunting and grazing pressure. To date, 32 nilgai have been captured and radio collared. Preliminary results show nilgai moving 15 miles from their capture location.

Roundworm in Raccoons—Raccoon roundworm primarily uses the raccoon as its host, but has also been found in more than 90 species of North American wildlife. In non-raccoon hosts, including humans, this parasitic nematode causes severe neurological disease, often damaging visceral and ocular tissues. NWRC scientists studied the presence of raccoon roundworm in raccoons in a semi-arid region of Texas. Of 19 raccoons captured, three had raccoon roundworm. Scientists note that to reduce the risk of raccoon roundworm range expansion and transmission to other species in semi-arid regions of Texas, it may be necessary to limit supplemental feeding activities and/or restrict feed consumption by raccoons.

Selected Publications:

Campbell, T. A., S. J. Lapidge, and D. B. Long. 2006. Using baits to deliver pharmaceuticals to feral swine in southern Texas. Wildlife Society Bulletin 34:1184-1189.

Long, D. B., T. A. Campbell, and S. E. Henke. 2006. Baylisascaris procyonis (Nematoda: Ascaridoidea) in raccoons (Procyon lotor) from Duval County, Texas. Texas Journal of Science 58:281-285.

Wyckoff, A. C., S. Henke, T. A. Campbell, D. Hewitt, and K. Vercauteren. 2005. Preliminary serologic survey of selected diseases and movements of feral swine in Texas. Proceedings of the Wildlife Damage Management Conference 11:23-32.

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Investigating the Ecology, Control, and Prevention of Terrestrial Rabies in Free-ranging Wildlife

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National Wildlife Research Center Scientists Develop New Methods Strategies to Reduce Rabies Transmission from Infected Wildlife to Humans, Domestic Animals, and Wildlife

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research organization devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and acceptable methods, tools, and techniques.

Increased urbanization, greater acceptance and desire of living closer to free-ranging wildlife, and increasing wildlife numbers have led to increased conflicts between people and wildlife. Such conflicts can take many forms, both direct and indirect. Recently, the potential for the transmission of diseases among wildlife, livestock, and humans has received greater attention.

Rabies is an acute, fatal viral disease most often transmitted through the bite of a rabid mammal. It can infect people as well as animals. Impacts to society from this and other wildlife diseases can be great. For instance, the cost of detection, prevention, and control of rabies in the United States is approximately $300 million annually.

In 2000, the United States Secretary of Agriculture enacted a Declaration of Emergency for rabies, citing threats to livestock and to public health and safety. In 2001, NWRC initiated research that could reduce or eliminate the transmission of this disease.

In the United States, terrestrial rabies can be found in many wild animals, including raccoons, skunks, gray fox, arctic fox, and coyotes. In an effort to halt the spread and eventually eradicate terrestrial rabies in the United States, NWRC scientists are conducting research on the behavior, ecology, movements and population structures of raccoons and gray fox. They are also evaluating methods and techniques used to vaccinate free-roaming wildlife against rabies.

Major Research Accomplishments:

- WS developed new bait designs that have more effectively delivered oral rabies vaccine to wildlife, including skunks and raccoons.
- WS scientists developed the use of infrared technology to detect signs of rabies infection in raccoons and possibly other mammals.
- WS determined that the rabies vaccine, V-RG, is safe for use in additional wildlife species.
- WS scientists are in the process of conducting experimental studies to test a new vaccine formulation to further stabilize the V-RG rabies vaccine that will increase vaccination rates in raccoons and other wildlife.

Applying Science and Expertise to Wildlife Challenges

Ecological and Genetic Studies on Gray Fox—NWRC scientists are learning more about gray fox ecology and genetics in Texas. The information gathered will help improve the effectiveness of the gray fox oral rabies vaccination (ORV) program in the state.

By combining radio telemetry, global positioning systems (GPS) collars, geographic information systems (GIS) habitat layers and population genetics data, scientists hope to answer questions regarding why breaks or breaches in a vaccination zone appear to occur only in select locations. Scientists want to know if it is due to habitat differences, sex-biased dispersal rates or other factors, such as long distance movements of juveniles.

Since early 2005, NWRC employees, in cooperation with Texas WS and the Texas Department of State Health Services, have been live-trapping and radio-collaring gray foxes inside and outside of the ORV zone. To date, over 200 DNA samples have been collected from gray fox, which may represent the largest DNA collection ever analyzed for this species.

Another major objective is to document fox movements, especially the potential of long-distance movements of gray fox. At present, at least one young male fox has moved over 13 km in a straight-line distance. This finding is significant because it indicates that male gray fox can move considerable distances and potentially breach an ORV

zone. Once paired with the population genetics data, this type of information will provide key insights into gray fox ecology as it pertains to ORV strategies.

Support for Raccoon Rabies ORV Program—Since 1995, WS has been involved in a national rabies prevention and oral rabies vaccination (ORV) effort. In support of this program, NWRC scientists conducted a pen study to determine the longevity of the oral V-RG (Merial, Ltd.) rabies vaccine that is currently being used by WS to combat rabies in raccoons. Results showed that the vaccine prevented rabies infection in many raccoons up to 18 months post-vaccination.

NWRC scientists also developed a method using infrared thermography to detect signs of rabies in raccoons. Thermography is a technique that detects and measures variations in the heat emitted by various regions of the body and transforms them into visible signals that can be recorded photographically. Coupled with the knowledge of diseases and their clinical signs, this technique could potentially be used to detect and measure increases in an animal's body surface temperature at specific areas of the body in relation to a particular disease. In the case of rabies, heat associated with viral activity is most prevalent in the nose and rostrum area and shows up as white (hot) or bright red (very warm) on thermal images. The use of infrared thermography in the initial screening and surveillance of diseases, such as rabies, could potentially save millions of dollars for public health and wildlife management agencies.

Current field research is evaluating the risks, possible routes, and prevention strategies associated with the spread of the raccoon rabies across Ohio from infected areas in extreme northeastern Ohio. Scientists are also using genetics to evaluate the trafficking of raccoon rabies across ecosystems in Alabama, Ohio, and Pennsylvania.

Groups Affected By These Problems:

- U.S. citizens
- Wildlife and natural resource managers
- Livestock producers and farmers
- Sporting organizations
- Consumers

Major Cooperators:

- Auburn University
- The Ohio State University
- Pennsylvania State University
- State Departments of Public Health
- Texas A&M University
- University of Northern Arizona
- WS Operations personnel
- Colorado State University
- Centers for Disease Control and Prevention
- MERIAL (private vaccine development company)
- FoodSource (private bait company)
- Texas State Health Services Department
- Ohio Department of Health Services

Selected Publications:

Dunbar, M. R., and K. A. MacCarthy. 2006. Use of infrared thermography to detect signs of rabies infection in raccoons (Procyon lotor). Journal of Zoo and Wildlife Medicine 37:518-523.

Slate, D., C. Ruprecht, M. Dunbar, and R. McLean. 2005. Oral rabies vaccination−a progress report. Proceedings of the Wildlife Damage Management Conference 11:12-13.

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Robinson S. J., S. M. Jojola, and K. C. VerCauteren. 2004. The role of bait manipulation in the delivery of oral rabies vaccine to skunks. Proceedings of the Vertebrate Pest Conference 21:194-197.

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Evaluation and Management of Chronic Wasting Disease Transmission

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National Wildlife Research Center Scientists Assess the Potential for Chronic Wasting Disease (CWD) Transmission Between Wild and Domestic Cervids and Develop Methods to Reduce/Manage the Disease

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research organization devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and acceptable methods, tools, and techniques.

As increased urbanization leads to a loss of traditional wildlife habitat, the potential for conflicts between people and wildlife increases. Such conflicts can take many forms, but recently the potential for the transmission of diseases among wildlife, livestock, and humans has received greater attention.

Major Research Accomplishments:

- WS determined the risk associated with direct and indirect contact between farmed and wild cervids at fencelines relative to the potential for CWD transmission.
- WS evaluated white-tailed deer and mule deer ecology along riparian areas relative to the transmission and spread of CWD.
- WS developed new methods to test for the presence of CWD in live and dead animals.
- WS determined the minimum fence height that deer cannot breach.
- WS identified focal sites where CWD is likely spread in the wild and is developing ways to disinfect these sites.
- WS is working to develop a CWD vaccine.
- WS is developing products to disinfect surfaces and areas contaminated with CWD.
- WS is helping to determine the origin and transmission routes of CWD.

Chronic wasting disease (CWD) is a fatal neurological disease that infects captive and wild cervids. North American cervids susceptible to CWD include white-tailed deer (Odocoileus virginianus), mule deer (Odocoileus hemionus), elk (Cervus elaphus), and moose (Alces alces).

CWD is caused by abnormal proteins that lack nucleic acids called prions. Prions change normal proteins in the host animal's cells resulting in concentrations of abnormal proteins. Over time, these abnormal proteins accumulate in the central nervous and lymphatic systems causing a degenerative lack of control and a "wasting-away" death.

There is no known cure or vaccine for CWD. The origin of CWD is unknown. The disease may have existed in the wild or began in captivity under abnormally high deer densities. CWD was first observed in 1967 at the Colorado Division of Wildlife's Research Facility in Fort Collins, CO, where it was initially believed to be malnutrition. In 1977, CWD was determined to be a transmissible spongiform encephalopathy and the first infected wild animal, an elk from Rocky Mountain National Park, was diagnosed in 1981.

NWRC scientists are working to develop methods to reduce the transmission and spread of CWD.

Applying Science and Expertise to Wildlife Challenges

Interactions of Wild and Farmed Cervids through Game-Farm Fences—NWRC biologists used track plots and motion-activated video to determine how farmed and wild cervids (mule deer, white-tailed deer, and elk) interacted through game-farm fences. The primary objective was to determine the degree of risk for disease transmission along

game-farm fences. Contact between farmed and wild white-tailed deer was less common than between farmed and wild elk, though potential for direct and indirect contact does exist. The least contact occurred where there were double woven wire fences. NWRC scientists are currently determining the effectiveness of electric fence in conjunction with a single woven-wire fence for reducing contact.

Ability of White-tailed Deer to Jump Game-Farm Fences—Deer can breach fences by going over, through or under. One concern is that wild deer will jump the fences into captive deer farms, thus exposing those deer to disease. Officials in APHIS' Veterinary Services program are currently developing fencing recommendations that will be required for captive cervid operations to be in compliance with the VS program to control CWD. Agencies need information on the ability of deer to breach fence systems.

As an initial step in determining the minimum fence height that deer cannot breach, NWRC scientists reviewed the literature and anecdotal evidence and conducted field tests on the containment efficiency of fence systems under different motivation scenarios for deer. Human drivers and humans plus dogs were used to motivate deer to breach fence systems. All deer successfully cleared the test fences when fence height was set at 3, 4, or 5 feet. When fence

height was set at 6 feet, 91 percent of deer cleared the fence. At a height of 7 feet only 10 percent of the deer jumped the fence, and no deer cleared the fence at 8 feet. These results will be useful in setting standards for fence height for security and containment of captive deer herds.

Transmission and Spread of CWD—CWD is spread from animal to animal by direct contact (i.e., nose-to-nose) or by contamination of feed or environment with saliva, urine, and/or feces. CWD can also be transmitted through the environment in soil contaminated by decomposing carcasses. The spread of CWD likely occurs by two main conduits: 1) through the natural dispersal and migration of wild cervids, and 2) by the inter- and intra-state transport of captive farmed cervids.

In western Nebraska, where CWD occurs, NWRC is using telemetry to learn about the ranges and movements of mule and white-tailed deer. At the same time, surveillance is being conducted at the county level to locate infected deer, particularly along the North Platte River. The potential exists for CWD to move east along the river rather quickly if management actions are not taken. NWRC researchers are also continuing a long-term study of the ecology of deer along the Missouri River. Data from these studies are being used in the development of movement models and formation of management decisions.

Sanitation and Decontamination CWD-infected Surfaces and Sites—Meat processors, hunters, farmers, and other constituents need effective methods and techniques for eliminating the spread of CWD and other transmissible spongiform encephalopathies (i.e., Bovine Spongiform Encephalopathy, scrapie, Crutzveld-Jacob Disease). NWRC scientists are developing an enzymatic product that breaks down prion proteins, rendering them harmless. This product could potentially be used to sanitize and decontaminate tools, surfaces, facilities, mineral licks and other areas infected with transmissible spongiform encephalopathies.

Development of Efficient Means to Detect CWD in Cervids—NWRC scientists and collaborators are developing more efficient methods for detecting CWD in both dead and live cervids. Current tests on dead animals are expensive and time-consuming, which limit the number of animals tested. Live tests are quite invasive, require anesthesia and are only effective for deer. With collaborators, NWRC scientists developed a rectal biopsy test for CWD that works on living or dead cervids, is easy to perform and can be repeated on individuals over time. NWRC scientists are currently working with State and Federal agencies to test and validate this new tool.

Vaccine Development—NWRC scientists have developed two experimental CWD vaccines that performed well in a mouse model. Efforts are underway to evaluate these candidate vaccines in deer. This will be the first evaluation of a vaccine for CWD in cervids. At the same time, NWRC scientists are attempting to further optimize the candidate vaccines and improve their performances in the mouse model.

Determination of Focal Points for CWD Transmission in the Wild—Through research with animal-activated cameras, NWRC scientists are quantifying cervid visits to focal sites, such as mineral licks and wallowing areas, and documenting behaviors that could lead to disease transmission. For white-tailed deer, results show that the male breeding activity of establishing scrapes as signposts for communication are likely a means of disseminating and contracting the disease. In addition, for deer, elk, and moose, results show that mineral licks are likely to be focal sites for disease transmission. As modes for disease transmission become better understood and decontamination methods are developed, this information will help pinpoint specific areas for management activities.

Testing of Prion Inactivation Methods—Prions, the causative agent of CWD, bovine spongiform encephalopathy, and the other transmissible spongiform encephalopathies, are extremely stable and difficult to denature. Because of this, using by-products and disposing of waste (i.e., potentially infected carcasses) is difficult as the materials may be infectious. Chemical digestion is thought to be an effective means of rendering infectious material. With collaborators, NWRC scientists are investigating whether digestion truly renders infectious material non-infectious. If so, these materials could be used for producing products like pet foods and bio-fuel.

Groups Affected By These Problems:

- Wildlife and natural resource managers
- U.S. citizens
- Livestock producers and farmers
- Sporting organizations
- Consumers
- Meat processors
- Rural communities
- State and federal agriculture and wildlife agencies

Major Cooperators:

- USDA/APHIS/Wildlife Services
- USDA/APHIS/Veterinary Services
- University of Nebraska
- Colorado State University
- State Departments of Public Health
- Wisconsin Department of Natural Resources
- Colorado Division of Wildlife
- Michigan Department of Natural Resources
- University of Wisconsin
- Cervid Research and Recovery Institute
- Private elk farmers

Selected Publications:

Seamans, T. W., and K. C. VerCauteren. 2006. Evaluation of ElectroBraid™ fencing as a white-tailed deer barrier. Wildlife Society Bulletin 34: 8-15.

VerCauteren, K. C., J. M. Gilsdorf, S. E. Hygnstrom, P. B. Fioranelli, J. A. Wilson, and S. Barras. 2006. Green and blue lasers are ineffective for dispersing deer at night. Wildlife Society Bulletin 34: 371-374.

VerCauteren, K. C., M. J. Lavelle, and S. E. Hygnstrom. 2006. Fences and deer-damage management: a review of designs and efficacy. Wildlife Society Bulletin 34:191-200.

VerCauteren, K. C., M. J. Lavelle, and S. E. Hygnstrom. 2006. A simulation model for determining cost-effectiveness of fences for reducing deer damage. Wildlife Society Bulletin 34: 16-22.

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Reducing Wildlife Damage With Chemistry, Biochemistry and Computer Modeling Research

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National Wildlife Research Center Scientists Use Chemistry to Resolve Wildlife Damage

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research facility devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and acceptable methods, tools, and techniques.

Due to the increasing need for new, Federally-approved chemical tools that can be used by wildlife damage management professionals, NWRC scientists have begun a project devoted to developing methodologies to identify, analyze and develop new drugs, repellents, toxicants, DNA markers and other chemistry-based wildlife damage management tools. These methodologies are used to support U.S. Environmental Protection Agency (EPA) and U.S. Food and Drug Administration (FDA) registration requirements. NWRC scientists are experienced in a variety of scientific disciplines, including metabolism chemistry, environmental fate, chemical synthesis, toxicology, chemical ecology, molecular genetics, computer modeling and formulation chemistry.

Studies include, but are not limited to:

1) Developing alternative chemical tools (toxicants, repellents, contraceptives, and attractants) to reduce bird damage to rice and sunflower crops, to control Canada geese in urban and suburban settings, and to facilitate selective removal of predatory canids.

2) Developing DNA fingerprinting to census wildlife densities of problem species, to identify pest animals, and to monitor movement of pest wildlife.

3) Identifying existing products or naturally-occurring chemicals in plants that could be used as agents to protect against wildlife damage.

4) Developing formulations for increasing the effectiveness of wildlife damage management chemicals already in use.

5) Developing computer models to evaluate the efficacy and safety of pesticides to target and non-target wildlife.

The ultimate goal of these studies is to provide the data needed by EPA and FDA to successfully register chemicals for use as wildlife damage management tools.

Major Research Accomplishments:

- WS developed a Wildlife Molecular Genetics laboratory which develops methodology to identify pest wildlife and census pest wildlife populations. These methods are applicable to the selective removal of predatory canids and nuisance bears.
- WS developed a probabilistic computer model to estimate exposure and mortality associated with pesticide applications. This model is being used to estimate target and non-target mortality associated with application of the avicide DRC-1339 and the rodenticide diphacinone.
- WS research has shown that rodenticide bait acceptance and efficacy can be increased with the addition of malted flour to the bait matrix.
- WS laboratory and field research has shown that chlorophacinone and diphacinone can be safely used to control rangeland rodents.
- WS developed analytical chemistry methods to support the development of avian repellents (anthraquinone, caffeine) and fertility control agents (nicarbazin, diazacholesterol).

Applying Science and Expertise to Wildlife Challenges

Radio-Tracer Techniques—Scientists are using NWRC's state-of-the-art radioisotope laboratory to develop techniques for better understanding the metabolism, residues, degradation pathways, and mode of action for various chemicals (fertility agents, immobilizing agents, toxicants) of interest to APHIS. Current radio-tracer studies with alpha-chloralose (an immobilizing agent) may be used to support changes in use restrictions which would increase the value of this tool to the WS program and stakeholders.

Identification of Compounds—In an effort to develop effective repellents for pest birds and deer, NWRC scientists are conducting experiments with inexpensive proteins and other natural products. These studies indicate that animal-derived protein sources, such as gelatin and casein, may serve as non-lethal repellents for a variety of herbivores, such as deer and rabbits.

Analytical Methods for Risk Assessment—NWRC chemists are developing new or improved methods for determining the risk to nontarget animals posed by chemicals developed to reduce wildlife damage. Data on chemical residues found in treated

wildlife are critical for assuring that the proposed uses of these tools are accompanied by minimal risk to nontarget animals, humans and the environment. For example, NWRC chemists are analyzing DRC-1339 (an avicide) residues in nontarget and target birds collected from DRC-1339-baited sunflower and rice fields. Findings show that birds feeding on DRC-1339-baited fields pose little risk to scavenging or predatory wildlife. Similar analytical approaches are being used to assess the safety of acetaminophen to control brown treesnakes on Guam, using anthraquinone to reduce bird damage to lettuce and rice, and using diphacinone to control introduced rats on Hawaii. The residue data are used to develop computer models to estimate risk to target and non-target wildlife. The computer models are also being used to identify pesticide formulation and application strategies.

Groups Affected by These Problems:

- U.S. Citizens
- Agricultural producers
- Consumers of Agricultural products
- Industry groups
- Wildlife and natural resource managers

Major Cooperators:

- Colorado State University
- University of Florida
- University of California
- U.S. Food and Drug Administration
- U.S. Environmental Protection Agency
- U.S. Department of Defense
- California • Department of Food and Nutrition
- Hawaii Department of Natural Resources
- Lipha Tech, Inc.
- Kolfolk, Inc.
- Berryman Institute, Utah State University
- Wildlife Conservation Society
- ENSR Environmental Consultants
- Department of the Environment, Food and Rural Affairs, UK
- CIIT Institute for Health Research

Molecular Genetic (DNA) Based Wildlife Management Tools—Molecular genetic techniques have been developed to identify the species, sex and genetic relationships of wildlife. These techniques are being applied to census wildlife populations through the collection of hair and scat and to identify the species and/ or pack of predators via the analysis of saliva recovered from predated carcasses. These techniques may facilitate the selective removal of pest wildlife and provide managers with information about the effectiveness of a variety of wildlife management activities related to predator control and wildlife disease issues.

Chemistry Support for NWRC Scientists—NWRC's Analytical Chemistry Laboratory provides support for all research projects being conducted at the Center's headquarters in Fort Collins, CO, and the Center's field stations located throughout the United States. This chemistry assistance supports a number of research topics, including avian infertility; bovine tuberculosis; rabies; wildlife hazards to aviation; wildlife damage to forest resources; bird damage to rice, sunflowers, and aquaculture; and waterfowl disease.

Selected Publications:

Kimball B. A. and D. L. Nolte. 2006. Development of a new deer repellent for the protection of forest resources. Western Journal of Applied Forestry 21:108-111.

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Johnston, J. J, D. L. Nolte, K. R. Perry, J. C. Hurley and B. A. Kimball. 2005. Assessing the potential of malted grains to increase bait acceptance by rodents. Crop Protection 24:381-385.

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Primus, T. M., B. A. Kimball, J. C. Hurley, J. J. Johnston, S. Blom and P. J. Savarie. 2005. Stability of Tranquilizer Drug Propionylpromazine Hydrochloride in Formulated Products. Pest Management Science 61:605-611.

Fagerstone, K. A., J. J. Johnston, and P. J. Savarie. 2004. Predacides for Canid Management. Sheep and Goat Research Journal 19:76-79.

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Stahl, R. S., J. H. Homan, G. M. Linz, and J. J. Johnston. 2004. Using fatty acid profiles to assess dietary intake of sunflower in red-winged blackbirds. Proceedings of the Vertebrate Pest Conference 21:87-91.

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United States Department of Agriculture

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FY 2006

Economic Research of Wildlife-caused Agricultural, Public Health and Natural Resource Impacts

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National Wildlife Research Center Scientists Conduct Benefit-cost Analyses to Assess Wildlife Damage, Disease and Management Impacts

The Wildlife Service's (WS) National Wildlife Research Center (NWRC) is the only Federal research organization devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective and acceptable methods, tools, and techniques.

The scope of wildlife damage management activities continues to expand as conflicts with humans and wildlife increase. New wildlife diseases (e.g., hantavirus, bovine tuberculosis, and chronic wasting disease) may cause risks to human health, livestock production, and wildlife populations. Many municipalities throughout the United States face nuisance and contamination problems posed by increased populations of urban, resident Canada geese. Predators can deter recovery efforts for certain endangered and threatened species, such as the California least tern.

NWRC seeks to quantify the benefits and costs of new and traditional wildlife management activities. NWRC's economists seek to quantify the potential savings (benefits) and costs derived from mitigating the impacts of wildlife diseases, wildlife damage to agriculture, property and natural resources and wildlife risks to public health and safety.

Major Research Accomplishments:

- WS conducted a comprehensive economic analysis of WS operational activities in California. Assuming that replacement programs were used and damage from wildlife would increase 25% to 100% in the absence of WS activities, it was projected that the value of WS operations in California ranged from $12.4M to $19.2M. In other words, for every $1 California counties invest in WS, they save $6.50 to $10.00 in wildlife damage and replacement program costs.
- WS performed an economic assessment of urban Canada goose damage and control efforts in the Puget Sound area. Results showed that lethal removal and egg addling were cost effective methods of reducing goose-related damage, but hazing of geese never proved cost effective. Non-discounted, benefit-cost projections yielded positive returns on investments whenever goose damage exceeded $200 per incident.
- WS studies documented the economic impact of the National Wildlife Research Center (NWRC) on the local economy. Construction expenditures at the NWRC created a temporary economic impact of $152 million throughout the State of Colorado. As this spending flowed through the economy, approximately 1,120 non-NWRC jobs were created. Non-construction expenditures added $9.6 million annually to the local economy and NWRC's annual budget alone created 88 non-NWRC jobs.
- WS determined the potential economic impacts to Hawaii if the invasive brown treesnake were to become established on the Hawaiian Islands. Results estimated annual expenditures to Hawaii for medical treatments, electrical outages, and tourism to be $351,706, $335 to $454 million, and $137.5 million to $1.4 billion, respectively.

Applying Economics and Expertise to the Challenges of Wildlife Damage Management

Economics Associated with Wildlife-transmitted Diseases—NWRC scientists are conducting benefit-cost analyses to quantify the potential savings and costs associated with selected wildlife diseases and disease mitigation methods. Collaboration with the WS Rabies Coordinator and Rabies Economic Team has led to empirical estimates of direct post-exposure rabies prophylaxis, public health costs and animal control expenses, as well as indirect patient expenses linked to wildlife rabies. Current research includes the analyses of potential benefits derived from the use of oral rabies vaccination (ORV) campaigns to control a domestic dog-coyote variant of rabies in south Texas. Results from these economic analyses provide an economic basis for government decision-making and serve as a guide for future ORV baiting campaigns in the U.S. and other countries.

Identify, Assess, and Quantify the Benefits and Costs of WS Operational Activities—Research is underway to develop benefit-cost and modeling procedures to quantify WS program activities. Approaches

integrate economic, biological and demographic data into profiles of local or regional (e.g., county-by-county) savings and costs attributed to WS activities. Four areas of potential benefits and costs have been identified: 1) agricultural protection (e.g., crop, livestock), 2) public health and safety (e.g., wildlife disease prevention, aircraft bird strike reduction), 3) natural resource protection (e.g., threatened species conservation through local predator management, archeological site preservation through rodent management), and 4) property protection (e.g., impoundment maintenance through rodent control, building safeguards through rodent management). Data is used to identify common "Species X Complaint" activities under each of the four factors. The approaches then involve (1) estimating "replacement" costs for WS (i.e., what will it cost to acquire/perform similar wildlife damage management services privately), (2) creating "projections" of hypothetical increases in damage in the absence of WS, (3) conducting "input-output modeling" to provide an analysis and estimation of regional, state, or county economic impacts and (4) defining "scenarios" to characterize best-worst case outcomes using WS or no WS programs. Additionally, novel vector-analysis and regression procedures are under development to quantify interactions between wildlife damage management methods (e.g., relocation, hazing, population reduction) and the timing of policy decisions (e.g., how and when to control populations of wild animals)

Benefits and Costs of Predator Management for Wildlife Protection—NWRC scientists are conducting studies to quantify the potential savings or increased revenues associated with predator management agreements aimed at protecting threatened and endangered species or enhancing game populations. Research efforts have focused on predator management agreements in several states, including California, Florida, and Wyoming, and the commonwealth of Puerto Rico. Studies have quantified the economic benefits of predator management as part of recovery programs of threatened California least terns and endangered Puerto Rican parrots. Current research involves the economic analyses of recovery efforts to Western snowy plover, sea turtles and Key Largo wood rats. Much of this work relates to data needed for National Environmental Policy Act (NEPA) compliance documents and requirements set forth in The Government Performance and Results Act.

Economic Surveys and Analyses to Quantify Wildlife-caused Damage—NWRC staff are engaged in collaborative efforts with private and municipal organizations to design and analyze economic impact surveys. For example, livestock organizations in several Eastern states have provided data to help estimate losses of newborn calves caused by black vultures. Ginseng producers in the midwest have provided data on crop losses caused by wild turkey.

Novel Wildlife Abundance Indices and Damage Assessment Methodology—New, time-/labor-saving methods are being developed to document wildlife damage. Efforts are focused on brushed-dirt-plot indices for relatively quick, easy, and inexpensive estimates of wildlife abundance and the effectiveness of WS management activities. These methods have resulted in rapid, reliable indices that show removing raccoons aids in sea turtle hatching success and that rodent ingestion of toxic baits correlates with lower population numbers.

Groups Affected by These Problems:

- Agricultural producers
- State county agricultural commissioners
- State public health agencies
- State natural resource agencies
- Wildlife Services managers
- U. S. citizens

Major Cooperators:

- California Department of Agriculture
- Departments of Economics and Ecology, University of Hawaii
- Economics Department, Colorado State University
- National Rabies Coordinator
- Texas Department of State Health Services
- Vertebrate Pest Research Advisory Committee (California)
- WS Operations Personnel

Selected Publications:

Sterner, R. T. and G. C. Smith. 2006. Modelling wildlife rabies: Transmission, economics and conservation. Biological Conservation, 131:163-179.

Shwiff, S. A., R. T. Sterner, J. W. Turman, and B. D. Foster. 2005. Ex post economic analysis of reproduction-monitoring and predator-removal variables associated with protection of the endangered California least tern. Ecological Economics, 53:277-287.

Engeman, R. M., H. T. Smith, R. Severson, M. A. Severson, J. Woolard, S. A. Shwiff, B. U. Constantin and D. Griffin. 2004. Damage reduction estimates and benefit-cost values for feral swine removal from the last remnant of a basin marsh system in Florida. Environmental Conservation, 31:207-211.

United States Department of Agriculture

Animal and Plant Health Inspection Service

FY 2006

Product Registration: Providing Tools for Wildlife Services

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National Wildlife Research Center Maintains Chemical Tools for Wildlife Damage Management

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research facility devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and acceptable methods, tools and techniques.

The NWRC Registration Unit is responsible for ensuring the registrations of WS chemical-based vertebrate management tools are current and meets State and Federal regulations. The Animal and Plant Health Inspection Service (APHIS) currently holds registrations for rodenticides, predacides, avicides, repellents, snake toxicants, immobilizing agents, and contraceptive agents. To maintain or expand authorized use of these products, the Registration Unit works closely with NWRC scientists to ensure that studies conducted for regulatory purposes meet U.S. Environmental Protection Agency (EPA) and U.S. Food and Drug Administration (FDA) guidelines. In addition, the Registration Unit responds to WS field personnel requests for new products or improvements to existing products. The Registration Unit also provides technical assistance and information to state WS programs, Federal and State agricultural and conservation agencies, academic institutions, nongovernmental groups, and private industry.

NWRC staff have coordinated two rodenticide registrant consortia: the Strychnine Consortium and the Zinc Phosphide Consortium. These consortia were established to collectively address EPA re-registration requirements for these compounds. Participation in these consortia has saved APHIS and other rodenticide registrants hundreds of thousands of dollars in data generation costs. Through the efforts of the Strychnine Consortium, all re-registration requirements were met and the consortium disbanded, a testament to the effectiveness of APHIS participation.

Major Research Accomplishments:

- WS worked with the U.S. Food and Drug Administration (FDA) to allow the use of alpha chloralose (AC), an immobilizing agent, to capture numerous bird species. AC is an effective tool for selectively removing individuals or small populations of animals from localized areas. Currently, FDA allows the use of AC to capture waterfowl, American coots, rock doves (pigeons), Canada geese, sandhill cranes and ravens. WS' continued use and demonstrated success in conducting capture operations has demonstrated that this technique is safe to both target and non-target species and is an important part of our tool box.
- During 2007, APHIS/WS will pursue EPA registration for GonaCon™ - an immunocontraceptive vaccine for white-tailed deer. An Experimental Use Permit application was submitted to conduct further field efficacy research on fallow deer at Point Reyes National Seashore, California. These data will be submitted to the EPA, to support use on other cervid species.
- WS is working cooperatively with the U.S. Fish and Wildlife Service and two private rodenticide manufacturers to register two rodenticide active ingredients–diphacinone and brodifacoum. This effort has resulted in the submission of three rodenticide registration applications to the EPA which would permit invasive rodent eradication on islands for conservation purposes.

Applying Science and Expertise to Wildlife Challenges

Vertebrate Control Pesticides—APHIS currently has nine active ingredients registered with the EPA which comprise a total of twenty product registrations. APHIS holds five individual product registrations for Compound DRC-1339, the only avicide authorized by the EPA. DRC-1339 is used to manage blackbird, pigeon and corvid problems in feedlots, agricultural fields, livestock birthing grounds, and locations where there are endangered species or human health concerns. APHIS also holds registrations for five rodenticide products. These products contain strychnine or zinc phosphide and can be used for a variety of rodent pests (e.g., rats, mice, ground squirrels, nutria, jack rabbits) in agricultural situations or for conservation purposes. Predator management for livestock protection continues to be an important function of WS. APHIS maintains registrations for Compound 1080, used only in the Livestock Protection Collar, and sodium cyanide, used only in the M-44

Cyanide Capsule. APHIS also maintains a registration for acetaminophen as a toxicant for brown treesnakes. A nonlethal alternative to toxicants is the avian repellent methiocarb; this registration allows wildlife managers to treat decoy eggs to protect endangered species' breeding grounds from raven predation.

As part of a cooperative effort among APHIS, the U.S. Fish and Wildlife Service and private industry, APHIS has submitted three registration applications to the EPA for rodenticide products used to eradicate invasive rodents from island ecosystems. Invasive rodent eradication on islands has proven to yield enormous benefits in the conservation of species or habitats in need of special protection. If registered as proposed, these products will provide natural resource managers the flexibility to design eradication programs with a high probability of success at a minimum cost.

Groups Affected by These Problems:

- Urban and suburban residents
- Farmers, ranchers, and livestock producers
- Natural resource managers

Major Cooperators:

- Wildlife Services operations
- U.S. Fish and Wildlife Service
- Private rodenticide registrants
- U.S. Department of Defense

Wildlife Contraceptives and Drugs—In November 2005, the Food and Drug Administration (FDA) relinquished regulatory authority over contraceptives used to manage wildlife and feral animals to the U.S. Environmental Protection Agency (EPA). The NWRC Registration Unit is currently preparing a registration application for the use of a GnRH-based immunocontraceptive vaccine (GonaCon™) for managing cervids (e.g., deer and elk). Because cervid management is the responsibility of state fish and wildlife agencies, APHIS is working closely with the Association of Fish and Wildlife Agencies to ensure a registered product meets the needs of the states. Other contraceptives under investigation for wildlife management include porcine zona pellucida for cervid and canine management and DiazaCon™ for management of monk parakeets, ground squirrels and prairie dogs.

APHIS maintains two Investigational New Animal Drug (INAD) authorizations from the FDA for immobilizing agents used in wildlife management, alpha-chloralose and propiopromazine hydrochloride. Alpha-chloralose is used to remove problem birds in urban and suburban settings. Propiopromazine hydrochloride is a tranquilizer used in conjunction with leg-hold predator traps to sedate captured animals, thereby reducing self-inflicted injury prior to the animals' removal from the trap.

Selected Publications:

Bynum, K.S., J.D. Eiseman, G.C. Weaver, C.A. Yoder, K.A. Fagerstone, and L.A. Miller. 2007. Nicarbazin OvoControl G bait reduces hatchabilty of eggs laid by resident Canada geese in Oregon. Journal of Wildlife Management 71(1):135-143.

Bynum, K.S., C.A. Yoder, J.D. Eisemann, K.A. Crane, and L.A. Miller. 2005. Development of nicarbazin as a reproductive inhibitor for Canada geese. Proceedings of the Wildlife Damage Management Meeting 11:179-189.

Johnston, J. J., W. C. Pitt, R. T. Sugihara, J. D. Eisemann, T. M. Primus, J. Crocker, M. J. Holmes, and A. Hart. 2005. Probabilistic risk assessment for snails, slugs and endangered honeycreepers in diphacinone baited areas on Hawaii, USA. Journal of Environmental Toxicology and Chemistry 24:1557-1567.

Primus, T. M., D. J. Kohler, C. A. Furcolow, M. J. Goodall, J. J. Johnston and P. J. Savarie. 2004. Determination of acetaminophen residues in whole body brown treensnakes. Journal of Liquid Chromatography and Related Technologies 27(5):897-909.

Vertebrate control products currently registered or approved for use by USDA APHIS

Regulated Products	Species Controlled	Uses Unique to APHIS
	RODENTICIDES	
Zinc Phosphide (3 products)	Voles, mice, rats, hares, woodchucks, ground squirrels, muskrats, nutria, prairie dogs	Some
Strychnine (4 products)	Pocket gophers	No
Gas Cartridge (1 product)	Prairie dogs, ground squirrels, woodchucks, marmots	Some
	PREDACIDES	
Large Gas Cartridge (1 product)	Coyotes, red foxes, striped skunks	Yes
M-44 Cyanide Capsules (2 products)	Coyotes, red foxes, gray foxes, arctic foxes, feral dogs	Some
Compound 1080 (Livestock Protection Collar)	Coyotes	Yes
	AVICIDES AND AVIAN REPELLENTS	
Compound DRC-1339 Concentrate (4 labels)	Gulls, pigeons, ravens, crows, magpies, starlings, blackbirds	Yes
Compound DRC-1339 Concentrate—Feedlots	Blackbirds, starlings, grackles, cowbirds	Some
Mesurol Aversive Conditioning Egg Treatment	Crows, ravens	Yes
	SNAKE TOXICANT	
Acetaminophen	Brown treesnakes	Yes
	IMMOBILIZING AGENTS	
Alpha-chloralose	Geese, ducks, coots, pigeons, ravens	Yes
Tranquilizer Trap Device (Propiopromizine HCL)	Wolves, coyotes, feral dogs	Yes
	CONTRACEPTIVE AGENTS	
Porcine Zona Pellucida	Deer, coyotes, prairie dogs, other rodents	Some
Gonadotropin-releasing Hormone	Deer, coyotes	Yes
Diazacon	Prairie Dogs	Yes
	REPELLENTS	
Cinnamon, Clove and Anise Oils	Brown treesnakes	Yes
	EGG-OILING AGENT	
Corn Oil	Canada geese	Yes

United States Department of Agriculture

Animal and Plant Health Inspection Service

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Expanding Research Capabilities Through New Construction

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National Wildlife Research Center Builds New Research Facilities

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research facility devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and acceptable methods, tools, and techniques.

APHIS WS is committed to completing its Master Plan to build research facilities that will permit NWRC to continue its role as a world leader in providing science-based solutions to the complex issue of wildlife damage management.

Applying Science and Expertise to Wildlife Challenges

Invasive Species Research Building—In 2006, NWRC completed construction of a new APHIS WS Invasive Species Research Building, located at NWRC's headquarters site on the Foothills Research Campus of Colorado State University in Fort Collins, CO. This 25,000-square-foot indoor animal research building provides a secure location for researchers to study invasive species that threaten our nation's natural resources. Many invasive species also carry parasites and diseases that can impact U.S. agriculture and native wildlife. The design of this new building will ensure that neither the species themselves nor any parasites or diseases they may carry can escape.

This new facility provides a unique opportunity for NWRC researchers to study the behavior of invasive species and test new

wildlife damage management methods in a controlled setting. Examples of invasive species that are being or will be studied include brown treesnakes from Guam, Coqui frogs from the Caribbean, Gambian pouch rats from western Africa, Monk parakeets from South America, roof rats from Southeast Asia, and nutria from South America.

The need for this research is especially important as international trade and travel continue to increase, introducing more invasive species into the United States. Each year, scientists discover new invasive species that have already become established in the United States. Their impacts can be far reaching. For example, invasive tree frogs, introduced into Hawaii via shipments of nursery plants, carry parasites that can devastate a variety of plants, including orchids, which are especially prominent in Hawaii. The brown treesnake, accidentally introduced into Guam in the late 1940s or early 1950s, has already exterminated most of the island's native forest birds and fruit bats. With the simulated tropical climate capability of this new facility, NWRC scientists are better able to concentrate their research efforts on invasive reptiles and amphibians, like the brown treesnake and tree frog, as well as other invasive birds and mammals.

Animal Research Building BSL-3 Biocontainment Renovation—In 2006, APHIS/WS completed the renovation of a 2,500-square-foot bio-containment area within the existing Animal Research Building to bring that area up to Biosafety Level 3 (BSL-3) research standards. This newly renovated area provides critical BSL-3 laboratory space and animal holding/testing space for ongoing wildlife disease research and diagnostics being conducted at NWRC. This space will be supplemented by the Wildlife Disease Research Building space when it is completed in FY 2009.

Wildlife Disease Research Building—The Wildlife Disease Research Building, scheduled for completion in FY 2009, will be the last major building to be completed in the original 1990 NWRC Master Plan. The building will be a bio-safety level 3 Ag (BSL-3 Ag) biocontainment disease research facility with approximately 28,500 square feet of research, laboratory, animal holding and testing, and office space.

Many serious, emerging disease issues involve wildlife as hosts or potential hosts of diseases affecting domestic animal and/or human health. The bio-terrorism threat from some of these disease agents increases the need and urgency to address these issues. NWRC is currently involved in wildlife disease issues related to avian influenza, wildlife rabies, bovine tuberculosis, West Nile virus, chronic wasting disease, and pseudorabies. It is critical for APHIS to expand that involvement and improve capabilities to deal with emerging and invasive diseases of concern.

The Wildlife Disease Research Building will allow APHIS WS to support the initial surveillance, rapid response, vaccine assessment, and other research needs for emerging wildlife disease issues. Legislation mandates that USDA provide assistance upon request to State governments, private individuals, and other Federal agencies to control and prevent damage and disease caused or carried by wildlife. This future building will greatly enhance the ability of APHIS to provide this assistance. It will also provide important "surge" space for disease epidemic emergencies in the United States. In such emergencies, the NWRC facilities will be available for conducting BSL-3 laboratory work to address national concerns.

The Wildlife Disease Research Building will provide researchers with the capability to conduct both animal experimental infection studies and laboratory testing of disease agents that present a biosafety hazard to humans, domestic animals, or wildlife. It will also provide for bio-security of disease agents to prevent their accidental or intentional release or escape from the facility. Studies will evaluate wildlife species as reservoirs and vectors of disease, identify routes of transmission, and develop methods to reduce transmission among wildlife, livestock, and humans.